FROM
CHRISTOPHER NOLAN
INTERSTELLAR
PARAMOUNT PICTURES AND WARNER BROS. PICTURES PRESENT
IN ASSOCIATION WITH LEGENDARY PICTURES A SYNCOPY/LYNDA OBST PRODUCTIONS PRODUCTION
A FILM BY CHRISTOPHER NOLAN "INTERSTELLAR" MATTHEW McCONAUGHEY ANNE HATHAWAY
JESSICA CHASTAIN BILL IRWIN ELLEN BURSTYN AND MICHAEL CAINE COSTUMES DESIGNED BY MARY ZOPHRES MUSIC BY HANS ZIMMER
EDITOR LEE SMITH, A.C.E. PRODUCTION DESIGNER NATHAN CROWLEY DIRECTOR OF PHOTOGRAPHY HOYTE VAN HOYTEMA, F.S.F., N.S.C.
EXECUTIVE PRODUCERS JORDAN GOLDBERG JAKE MYERS KIP THORNE WRITTEN BY JONATHAN NOLAN AND CHRISTOPHER NOLAN
PRODUCED BY EMMA THOMAS CHRISTOPHER NOLAN LYNDA OBST THOMAS TULL DIRECTED BY CHRISTOPHER NOLAN
NOVEMBER 2014
IN THEATRES AND IMAX
LEGENDARY
InterstellarMovie.com

Published by Running Press,
A Member of the Perseus Books Group

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Printed in Hong Kong

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or e-mail special.markets@perseusbooks.com.

ISBN 978-0-7624-5683-3
Library of Congress Control Number: 2014940741

E-book ISBN 978-0-7624-5684-0

9 8 7 6 5 4 3 2 1
Digit on the right indicates the number of this printing

Running Press Book Publishers
2300 Chestnut Street
Philadelphia, PA 19103-4371

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INTERSTELLAR

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FOREWORD
CHRISTOPHER NOLAN

MUCH OF WHAT DREW ME to *Interstellar* is related to the great science fiction films of my childhood. The themes, characters and ideas of Jonah's original screenplay had an elemental power to them that kept speaking to me—but the thrill of taking on a huge movie about space travel also had a direct link straight to my earliest experiences of what movies can actually be. For any filmmaker my age, the impact of *Star Wars* is hard to overstate. I saw the film twelve times in the movie theater, then pored over magazines and books about the making of this epic, until my rudimentary grasp of the adventure of making the film had started to eclipse the adventure on screen. My earliest ideas about being a filmmaker involved fanciful concept designs, storyboards, miniature shoots—but it would be a long time before my own films would require such an approach.

The other influence of *Star Wars* is less direct—its success prompted MGM to rerelease *2001: A Space Odyssey*. My dad took me to see it at the Leicester Square Theatre in London. This experience has never left me, and its level of cinematic grandeur and audience immersion is set in stone as the standard to which any blockbuster must aspire. Information about the making of Kubrick's masterpiece was harder to come by than Lucas's, but I found out whatever I could and availed myself of these techniques wherever possible (the zero gravity sequences in *Inception* being an obvious example).

With *Interstellar*, my debt to these early inspirations reached a new level, casting a shadow of responsibility as we pored over spacesuit designs and discussed possible locations to represent distant planets. We wanted to live up to the great science fiction of the past, and add our own chapter to this epic book from storytellers who have tried to imagine where we might go and what might be out there.

Kip and Jonah's original grounding of the story in the possibilities of real world science set the tone for the entire production. Early on, we made a commitment to reality, to function over design, to a lack of futurism which would sidestep the distracting parlor game of trying to guess the design of the future. We wanted our future to be totally relatable, and the audience's attention focused on the substance of the story. Nathan, Mary, Hoyte and the rest of our team worked hard to see that the audience's belief would be suspended through even the most extreme encounters with the exoticism of the universe as described by Kip.

Kip is a man who has spent his entire life proving the maxim that truth is stranger than fiction, and his explanations of the science involved in interstellar travel always felt like springboards, not constraints. The deeper we went into space, the more intense the collaboration between Kip and our visual effects team. The resulting images were indeed beyond my wildest dreams.

This book details the efforts of a large group of talented people to make the most of the chance we were given to take the audience on an unforgettable journey. We tried never to let the sheer joy of playing in such a fantastic arena get in the way of our storytelling, but the pages here show just how hard it was to suppress the excitement of finally making exactly the kind of pure cinematic experience we'd always dreamed of.

OPPOSITE On the set of *Interstellar*, director Christopher Nolan discusses a key scene with lead actor Matthew McConaughey.

FOREWORD
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INTRODUCTION

KIP THORNE

BEFORE *INTERSTELLAR*, I had a half-century career as a professor of theoretical physics. I understand that the Professor Brand character in the film may have been modeled on me. Michael Caine told me so, but director Christopher Nolan never told me himself. Perhaps Chris didn't want me to get a swelled head.

I was exceedingly ignorant of filmmaking when I got involved with *Interstellar*. This book would have helped me a lot as a guide, as I stumbled through my contributions to the film, gawking at everything happening around me.

It was producer Lynda Obst who lured me to Hollywood. Together we authored a movie treatment in 2006 that became the seed for the first three drafts of *Interstellar*'s screenplay, written by Chris's brother, Jonathan "Jonah" Nolan, in the late 2000s. It was exciting to be included in discussions with Jonah and Lynda, as Jonah crafted his three drafts and then turned the screenplay over to Chris.

Although the final movie bears only a little resemblance to the story in Lynda's and my original treatment, it adheres to our vision that a wide range of real science be woven tightly into the film's fabric. It's been my pleasure to help Chris and Jonah do that weaving, from beginning to end.

Chris has remarkable intuition about science. We discussed the movie's science every few weeks from January through May of 2013, as he integrated Jonah's version of the screenplay with a script of his own, and transformed their union into *Interstellar*'s rich and complex final script. Sometimes our conversation would lead, organically, to new science ideas for the film. Other times, Chris would describe a new idea he was thinking to incorporate, and I'd respond on the spot that I didn't see how to make it fit with the physical laws that govern the universe. Then I'd go home, sleep on it, and in the middle of the night I would have an inspiration. The next morning I'd write Chris a note about how all was okay with his idea after all, or about how to make it work. And we'd sometimes follow up with a phone call to wrap up loose ends.

In May, as his screenplay neared completion, Chris sent visual effects supervisor Paul Franklin over to my home to talk about the movie's visual effects. I'm so naive that I didn't know who Paul was; only afterward did I discover he got the Academy Award® for the visual effects in Chris's movie *Inception*. Paul invited me to work with him and his team at Double Negative in London, to ensure that the images of *Interstellar*'s wormhole, its black hole Gargantua, and Gargantua's accretion disk were scientifically accurate. Thus began a wonderful, summer-long collaboration.

I fed to Oliver James—at Double Negative—equations describing the propagation of light rays through the warped space-time around black holes and wormholes. Oliver wrote a sophisticated computer code based on my equations. His code produced images of what stars, nebulae, and an accretion disk *really* would look like to a camera in orbit around Gargantua or traveling through the wormhole. I thought that was the whole story. But no . . . Absolutely essential were the rich artistic details added by Eugénie von Tunzelmann and others at Double Negative, especially the details of the galaxy in which Gargantua lives, and the accretion disk. The result, after much iterating and vetting by Paul and Chris, are the images you see in *Interstellar*: the first Hollywood movie ever to accurately depict black holes and wormholes and their environments.

In July and August 2013, with filming about to begin, I had independent emails from Matthew McConaughey and Anne Hathaway, asking to talk about the movie's science. Matthew and Anne were struggling to understand black holes, wormholes, quantum physics, and the fifth dimension—concepts that Anne's character, Dr. Amelia Brand, knows cold, and that Matthew's character, Cooper, learns as the film progresses. I had a two-hour meeting with Matthew and a ninety-minute phone call with Anne—two of the most interesting conversations I've had in a long time. I came away impressed with their smarts, their dedication, and their wide-ranging curiosity.

One day in October, with filming in Canada and Iceland finished and in-studio filming in full swing in Los Angeles, Emma Thomas—*Interstellar*'s lead producer and Chris's partner in life and film—toured me through the *Endurance* set. It was a full-scale mockup of the spacecraft's command and navigation pod: 44 feet long, 26 feet wide, 16 feet high; suspended in midair; able to shift from horizontal to nearly vertical; exquisite in detail. It blew me away and piqued my curiosity.

"Emma, why build these enormous, complex sets when the same thing could be done with computer graphics?" I asked. "It's not clear which would be cheaper," she responded. "And computer graphics can't yet produce the compelling visual details of a real set." Whenever possible, she and Chris used real sets and real practical effects.

The realism of Chris's sets was impressive. I spent several days in November on set in Professor Brand's office. A team led by Gary Fettis—the *Interstellar* set decorator—had borrowed from me a bunch of books and journals about astrophysics and gravity, to be used on the set. When I arrived to write equations on the Professor's sixteen blackboards, I discovered not only my stuff there but lots more relevant books and props that had been gleaned from elsewhere. It's testament to Chris's thoroughness and style that his sets are filled with rich realism, much of which never appears on screen but would if he had turned the camera in a different direction while filming.

I watched Chris direct Michael Caine as Professor Brand and Jessica Chastain as Murph in their scenes in his office. I was amazed at his skill and theirs in getting just the right nuance of voice and facial expression. And I was intrigued by the actors' different styles. Jessica was precise in her acting; from one take to the next, precisely the same words, vocal tones, and facial expressions unless directed otherwise. Michael varied his dialogue from take to take; no two takes were quite the same. And Chris seemed completely at ease with this. He and Michael have done six movies together.

Chris used just one camera, an IMAX®. He shot the same scene a half dozen or more times with the camera in one location, then a half dozen or so in another, and then in a third; by contrast, many directors would use several cameras simultaneously. As each take proceeded, he watched intently what the camera was seeing on a handheld monitor. At this pace, and with time for quietly instructing the actors and camera and sound crews between takes, that day of filming produced just one or two minutes of movie. No wonder filming began in August and didn't end until December!

ABOVE Christopher Nolan and Kip Thorne discuss interstellar phenomena.

One day in April 2014, during post-production, Chris asked me to visit the editing rooms near his home to consult with him and Lee Smith, the film editor, about the *Endurance*'s trip through the wormhole. There, I was amazed to see a dozen assistant editors, all working in parallel to bring the film's images into the forms that Chris and Lee wanted.

And in June, when Hans Zimmer's wonderful music, and other sounds, were being edited into the film, Chris and sound designer Richard King showed me the sound stage at Warner Bros., where a half dozen editors were working together. The movie's sounds—wind, rustling leaves, insects, birds, footsteps, soft music, and much, much more, all integrated together—filled the stage, a huge room the size and shape of a small movie theater. The sounds were exquisite, rich, and complex, like nothing I'd ever heard before. I stood there quietly, hypnotized.

And when I was shown an early cut of the full movie, I was overwhelmed. Although I knew the story and dialogue forward and backward, I found myself filled with emotion, and even crying as I watched Cooper struggle to reach his daughter. The compelling power of *Interstellar* is a testament not only to Christopher Nolan's genius but to the contributions of the huge team that worked with him, and to Chris's and Emma's skills at organizing and leading this huge team through a very complex production process. This book presents the in-depth story of their successful work together.

Only the voyager perceives the poignant loveliness of life, for he alone has tasted of its contrasts. He has experienced the immense and wild expansion of the spirit outward bound, and the contracted heartburn of the homecoming. He has explored the two infinities—the external universe—and himself.

—Rockwell Kent[1]

PART ONE
MISSION OF SURVIVAL

CHAPTER 1: THE ULTIMATE FRONTIER

A NEW BREED OF PILOT flew the lonely Mojave Desert sky in the 1950s, routinely risking death to push the limits of prototypal planes with names like *Skyrocket* and *Shooting Star*. Many test pilots were combat-tested in World War II or tangled with enemy MiGs over Korea. Some earned the title of "ace" for at least five confirmed kills: "Knights of the Right Stuff!" exulted Tom Wolfe, coining the ringing phrase that has come to define the first fliers of the dawning Space Age.[2]

One ace with the Right Stuff was Chuck Yeager, a standout in a firmament of indomitable airmen. In October of 1947, Yeager was assigned to fly the Bell X-1, a $6-million-dollar aircraft, the first capable of flying faster than sound. While horseback riding the night before the flight, Yeager was thrown and broke a couple ribs. But the next morning, broken ribs and all, Yeager and the X-1 were dropped from the bomb bay doors of a B-29 at 20,000 feet. He rocketed tens of thousands of feet higher, until he flew faster than anyone had ever flown—his breaking of the seemingly unassailable sound barrier was announced with the first sonic boom.[3]

In 1958, America turned to outer space when President Dwight Eisenhower formed the National Aeronautics and Space Administration (NASA). The short list of potential astronauts—literally "star voyagers"—included submarine crew, deep-sea divers, arctic explorers, even parachute jumpers.[4] But it was test pilots who made up the seminal Mercury program, what *Life* magazine called "the supremely dramatic story of man's first efforts to leave his native Earth."[5]

Recapturing the early space program's spirit of adventure is one of the driving themes behind director Christopher Nolan's *Interstellar*. Jointly produced by Paramount Pictures and Warner Bros. in association with Legendary Pictures, Nolan's company Syncopy Inc., and Lynda Obst Productions, *Interstellar* is Nolan's first film since *The Dark Knight Rises*, the final chapter in his epic Batman trilogy.

"I've always been interested in making a film about space because, to me, space exploration has always represented the ultimate frontier," Nolan explains. "It's about

OPPOSITE Matthew McConaughey as Cooper, displaying the laser-focused, forward gaze of the star voyager.

the absolute extremities of human experience and trying to define our place in the universe; what our existence means in the universe. For a filmmaker, that opens up an infinite set of possibilities in terms of putting characters at the extremes of what human beings have ever done and can ever imagine doing."

Interstellar is set during an unspecified time in the future, an era when the planet is running out of food. Cooper, the widowed head of a small, tight-knit family, is a former NASA pilot and engineer forced, like many, to scratch out a subsistence living on his family farm. Space exploration has become irrelevant in a starving world, but Cooper learns that NASA has been operating secretly for years and that the space agency wants him to pilot a mission to search for habitable worlds. It will be a true star voyage, traversing an interstellar wormhole near Saturn to a distant galaxy, a journey beyond space and time—but Cooper pledges to his daughter that he will come back to her.

The production adhered to Nolan's preference for realism and getting visual effects shots "in-camera" wherever possible, a daunting challenge given the story's interstellar journey. Instead of depending on greenscreen and replacing those placeholder spaces with computer-generated

effects in post-production, every aspect of filming would be grounded in tactile reality, from the lay of Cooper's farmland to the control switches in his spacecraft.

"No one handles the sheer mass and scale of a world as well [as Christopher Nolan], in my opinion," says actor Matthew McConaughey, who plays Cooper. "Part of why it works so well is he goes from intimacy, heart, humanity, and very personal things to the vast scope. [A Nolan production] is an incredibly tightly run ship. If there's a huge stunt that's [supposed to take] two days, he'll have that son of a bitch shot before lunch on the first day. Before the smoke has cleared, he's like: 'Next!'"

"I'm not a big fan of greenscreen, because you get color pollution [green "spill" on the live-action photography], and there are a lot of tricky issues to deal with," Nolan says. "And it's very, very uninspiring to shoot with greenscreen because you're not looking at anything; you're only looking at the foreground. I wanted the actors to really feel they were in the environments. I've always taken the approach of trying to do as much in-camera as possible, because I think you just get something you can believe in. Audiences today have spent decades watching computer-generated imagery, and they're very, very good at spotting it. If you can present something they haven't seen before, something real, you get a moment that means more.

"The real focus for me, in terms of the execution of the film, was to try to put the audience into the spaceships, and into the shoes, of the astronauts exploring these new worlds and new galaxies," Nolan continues. "We decided to use a lot of different technological approaches to [realize] that. We were shooting in large-format IMAX® photography, and we built very realistic sets that could put the actors and the audience into the capsule-type environments necessary for this kind of space exploration. We also traveled across the world to try to get the scale and geography [for other planets], to give the audience a tactile sense of the journey the characters go through. That's what I'm really excited about, for the audience to get a sense of the spectacle of a great interstellar journey."

The approach included grounding the conjuring of theoretical phenomena—wormholes, black holes, time

> "It's about the absolute extremities of human experience and trying to define our place in the universe."

travel—in hard science, with technical advice provided by renowned astrophysicist Kip Thorne. "It would have been easier to take a fictional approach, without thinking about scientific realities," says Emma Thomas, Nolan's producing partner and wife. "But the whole idea of this being about real space had been integral to the project from the beginning."

Thorne had been involved with *Interstellar* when it began gestating at Paramount in 2006. Producer Lynda Obst was developing the film, with Steven Spielberg attached to direct. Christopher Nolan and Emma Thomas followed the project with interest—particularly as Christopher's brother, Jonathan "Jonah" Nolan, had been hired to write the original screenplay.

OPPOSITE Cooper is a born pilot and engineer. **BELOW** In an emotional moment, Cooper and his daughter Murph (Mackenzie Foy) stand hand in hand in a cornfield at their family farm.

THE PREMISE

The Nolan brothers' interest in interstellar travel was given an early boost thanks to their uncle Tony, who worked on components for the *Saturn* rocket and would share Super-8 films of the launches with his nephews. "I remember Chris using some of these films to enhance the visual effects for one of his earliest stop-motion efforts," Jonathan says. "We grew up fascinated with these Super-8 films and the space program."

Subsequently, Jonathan was keenly interested when, many years later, he was approached as a prospective screenwriter for *Interstellar*, then a few months in development. The seeds of the project were sown when Carl Sagan introduced Lynda Obst to Kip Thorne. Obst, a *New York Times* editor before entering the movie business, edited Thorne's best seller, *Black Holes and Time Warps*, and became intrigued by his work.

In *Black Holes and Time Warps*, Thorne asserts that wormholes "are not mere figments of a science fiction writer's imagination." In fact, Austrian physicist Ludwig Flamm mathematically discovered them in 1916, in response to Albert Einstein's historic equations on the structure of the universe.[6] Thorne, who began the modern era of wormhole research in the late 1980s, explains that the very term is inspired by a worm boring through an apple—from a cosmological perspective, the worm traveling over the apple's surface is analogous to traveling across the external universe, while going through the wormhole is a faster dimensional route to a distant point in the universe. Although Einstein's general relativity equation and the laws of physics point to the possibility of their existence, wormholes remain a mystery.

ABOVE Brand (Anne Hathaway) and Romilly (David Gyasi) are suited up and good to go. **OPPOSITE** Concept art depicting the launch site for the interstellar voyage that could save humanity.

"We know black holes are formed from collapsed stars, but we don't know how a wormhole would form," Thorne says. "But once a wormhole has formed, we understand them as well as we understand black holes. It's likely that wormholes don't form naturally in our universe, but they could be created artificially by a highly advanced civilization. But, as physicists, we don't have a clear idea of how a very advanced civilization would go about building one, although we can describe wormholes mathematically and discuss and analyze what is required to keep them open so you can travel through them."

> "We know black holes are formed from collapsed stars, but we don't know how a wormhole would form."

Jonathan Nolan began writing *Interstellar* in 2007, but lost a few months during that year's Writers Guild of America strike. He then stepped away to write The *Dark Knight Rises* with his brother. Spielberg was still attached to direct—until 2010, when his company, DreamWorks, left Paramount. "Our script was wholly owned by Paramount and stayed there," Jonathan recalls.

Christopher Nolan and Emma Thomas were then working on *The Dark Knight Rises*, and *Interstellar* represented the potential next project. "I got in touch with Paramount to see if we could work something out, with me taking over the project," Christopher Nolan says.

"For a long time, I've been interested in science fiction, and I thought the premise of this film was very exciting.

ABOVE Matthew McConaughey's Cooper in a contemplative moment. "Once we knew who would play Cooper it definitely informed our choices in terms of the other actors," producer Emma Thomas notes.
OPPOSITE TOP LEFT Concept art detailing the interior of the lander craft.
OPPOSITE TOP RIGHT An astronaut pilots a Ranger ship in this preproduction artwork.

"Jonah's script, and what Chris wanted to do with it, felt epic."

What I wound up doing was to take Jonah's original screenplay and fuse it with some other ideas I'd been working on for a long time."

For the final script, Christopher Nolan took Jonah's version and made it his own, building on his brother's initial ideas and creating something new and unique. "When [Chris and Jonathan] get their minds together, the [eventual movie] has a lot of stuff for an audience to be wowed and entertained by, but there's always a great emotional core," says Syncopy's executive producer Jordan Goldberg. "Jonah's script, and what Chris wanted to do with it, felt epic. 'What do science and space mean to humanity?' That was really appealing."

CHAPTER 2: THE LAUNCH

The *Interstellar* script went through a number of changes when Christopher Nolan took on the project. Ultimately, though, the director's big creative breakthrough came with a line that summed up the story he wanted to tell: "I was working on the script and seeing if I could 'crack' it, as we say, and I wrote the lines: 'Mankind was born on Earth. It was never meant to die here.' That became the important reason for making the film. Once I had that, I knew I could finish the script the way I wanted. *Interstellar* is about leaping forward in time and human experience. These other [sci-fi] projects I was working on were about how to approach the idea of relativity. I was fascinated by the idea of the massive time spans involved in interstellar travel and what that would do to people, the psychological and emotional issues for astronauts doing that kind of exploration."

Physicist Kip Thorne was intimately involved throughout the screenwriting process, providing advice and direction on integrating science into the story, from Jonathan Nolan's first drafts to Christopher Nolan's final script in August 2013. "When Christopher Nolan came on board, it was a pretty seamless transition," Thorne recalls. "His interest in the science was already there. He also had ideas for additional science he wanted to put in, and we discussed those ideas at great length from January to February [of 2013], as he was wrapping his head around the heavy transformation of the screenplay he was about to do."

Thorne remained actively involved in the production as the VFX team began visualizing the scientific phenomena explored in the film: "Built into this entire movie is science that is well understood, such as black holes; science that is right at the frontier of knowledge, such as the singularities inside black holes; and science beyond the frontiers where we have to do a lot of speculating, such as the fifth dimension."

Despite the infusion of this cutting-edge science, the emotional core of the story remained Cooper's connection to the family he'd leave behind. In Jonathan's script, Cooper had a special bond with his young son, Murph, whose name was retained in the new draft, although the character ultimately became a daughter. "What I love in

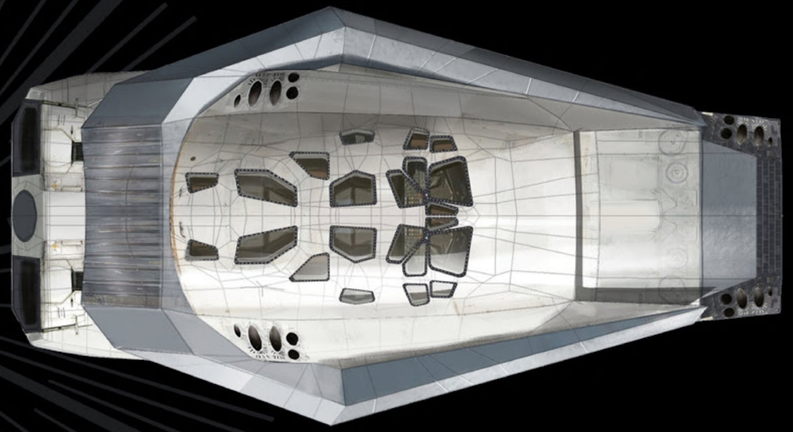
OPPOSITE In this dramatic piece of concept art, a lander breaks through a distant planet's atmosphere.

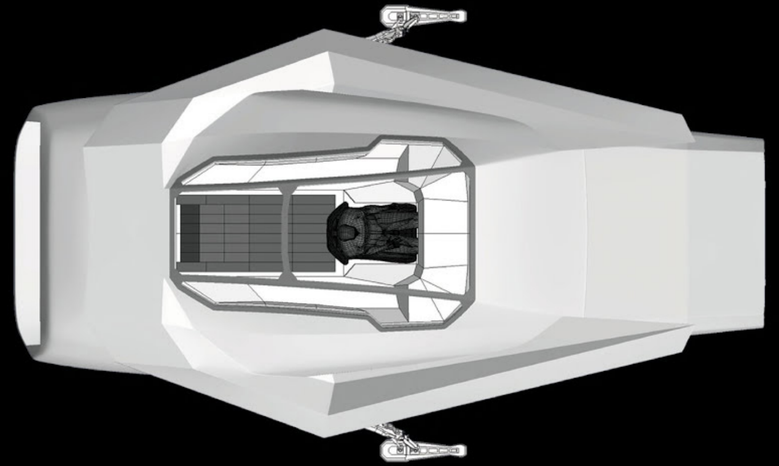
particular about the script is it's about space and science fiction and the future, but it's also about human resilience, with real relationships and a real family and how they strive to find a life for themselves," says Emma Thomas. "It's really about the impetus to find a new home."

BRAINSTORMING

The transition from written word to visual concepts began with Christopher Nolan and his longtime production designer Nathan Crowley dreaming up and discussing story ideas at Nolan and Thomas's home in a quiet residential section of Los Angeles. It was there, in the summer of 2003, that the director and Crowley developed *Batman Begins*; Nolan writing the screenplay in his studio, Crowley in the car-less garage, working up designs and rough models for the look of Batman's world. During breaks, they sat on a bench under an old tree in the yard, drinking tea and discussing the work in progress.[7]

In the summers since, the movies may have become even more complex, but the process there remains the same—director and production designer talking story, dreaming up the look of the film.





THESE PAGES The *Endurance* includes docking ports for four smaller craft, including the Ranger, a conventional transport and exploratory vehicle (*top left and right*). The three images at the bottom of the page show differing designs for a separate craft known as the mini-Ranger.

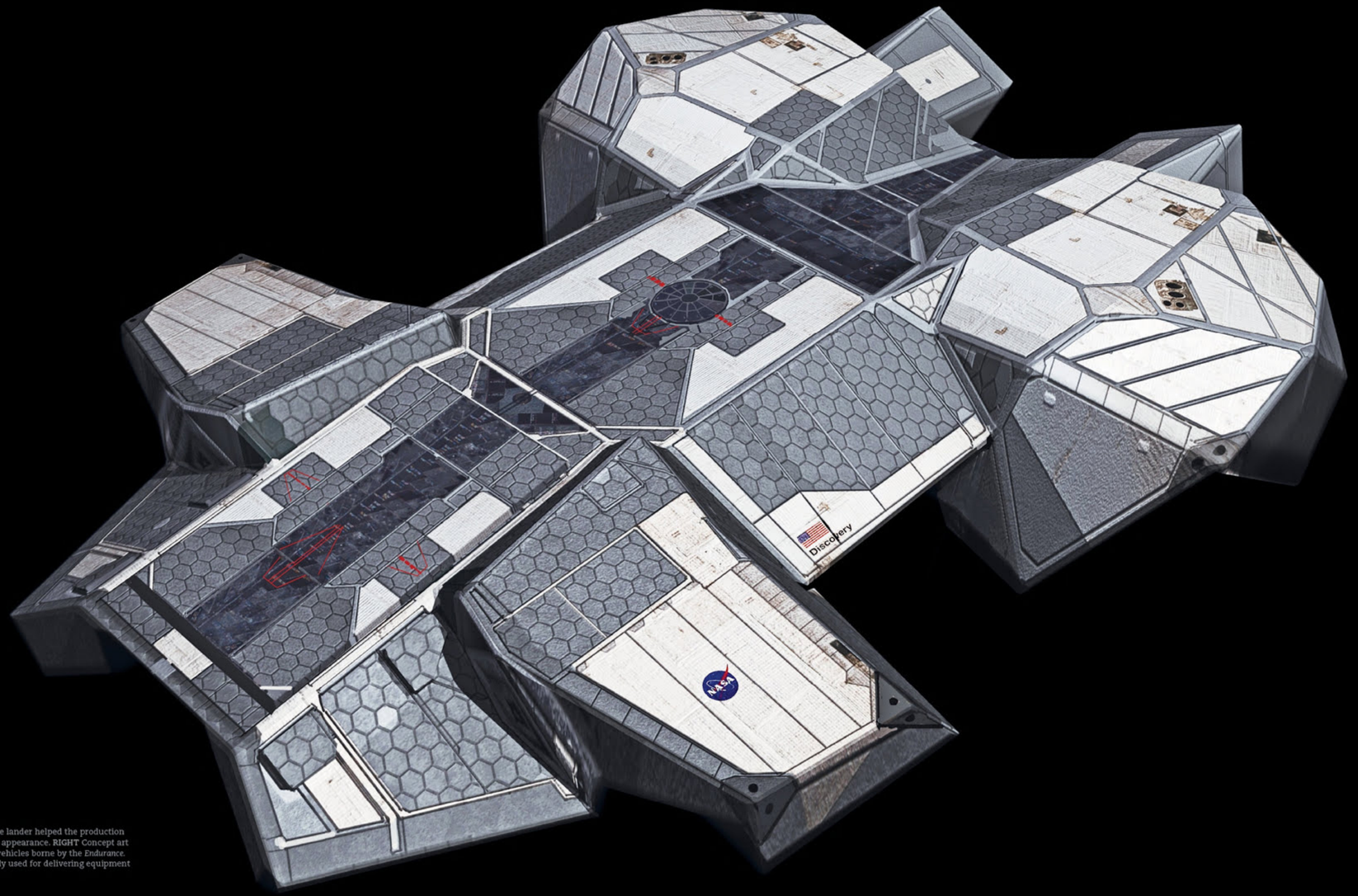
"[In the early stages] Chris is downloading his thoughts to me so I can kick off," Crowley reflects. "That's how we start. It's about bouncing ideas in terms of imagery. We've worked together so many times, there's an ease and familiarity that allows us to decide how to attack something, to get straight down to it, rather than go off on tangents. We start with thoughts and ideas and compiling references."

"It was very exciting to come back into that space and see what Chris and Nathan had started to articulate and build," Jonathan says. "Chris took the draft and started writing his ideas into it and was working with Nathan at the same time. A lot of the work was tackling that question of how do you visually represent the deeper structure of the universe? How do you represent four dimensions? We were playing at the periphery of the laws of physics."

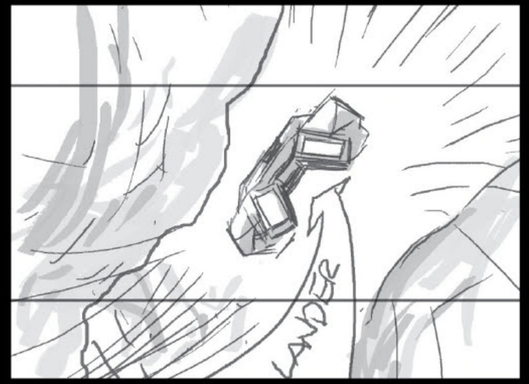
In addition to wormholes and black holes, the NASA mission encounters a phenomenon that Christopher Nolan and his colleagues call the Tesseract, the fourth dimension of time itself that intersects with a bedroom in Cooper's farmhouse. The Tesseract was the team's first conceptual challenge, a cosmic riddle that would take virtually the entire production to solve.

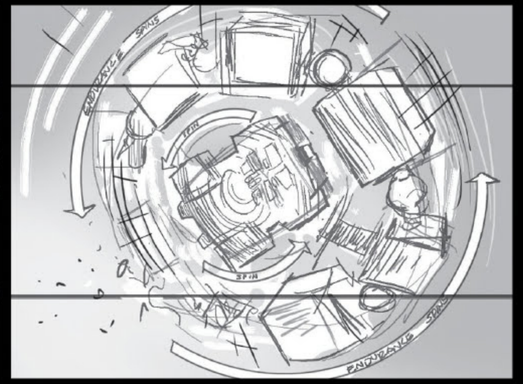
"Oddly, it was on the first day on *Interstellar*, while we were chatting away, that we thought we'd have a go at figuring out the Tesseract," Crowley recalls. "I'd been looking at these 'infinity rooms' [mirrored rooms where the surroundings seem to stretch off into infinity] and other repetitive ideas, so I had an interest in making an infinity prop in a bedroom with bookshelves, to see what that would look like, and that got the conversation going. Chris said, 'Why don't we knock up a model?' We got in the car and went down to the art store to buy stuff to make little models, continually talking about the story. I started off with the fact that we wanted the audience to feel that this could exist, like we normally do."

Along with the Tesseract, another key element of *Interstellar* would be the worn and familiar appearance of the technology used to travel through wormholes. America's pioneering space program inspired the look and feel, the production using the phrase "NASA aesthetic" as a guideline.



LEFT This small-scale model of the lander helped the production team visualize the craft's finished appearance. **RIGHT** Concept art shows the lander, another of the vehicles borne by the *Endurance*. The lander is a cargo ship primarily used for delivering equipment and supplies.





But their research, which included the space shuttle, the International Space Station, and today's entrepreneurial space travel programs, was not about a retro vision or the history of space exploration, Nolan explains. The essence of *Interstellar* was the adventure into the unknown.

"The ultimate heroism of explorers, whether it's on polar expeditions or going to the Moon, is they are putting themselves at the mercy of forces that cannot be controlled," Nolan explains. "We wanted to be true to that spirit of very stripped-down, robust exploration. [The astronauts of *Interstellar*] have no idea what they're getting into. They have to be able to repair the ship themselves, deal with all the technology themselves, so we didn't want overly fussy electronics. We wanted things to be very real, mechanical, and tactile."

Interstellar was a science fiction movie shorn of genre conventions. "What I said to Nathan was I didn't want to approach the idea of futurity in the design," Nolan says. "The film is set in the future, but I didn't want to engage in a parlor game of trying to predict trends in visual design. Everything in the design is purposeful and relates to some real world idea of mechanics. So, I told everybody to abandon the idea of what kind of trousers people would be wearing in the future. You'll never get it right, anyway, because your design ideas and concerns are always a reflection of the present. What I wanted—my insistence—was that everything on the set, every switch or whatever, have a purpose."

The digital effort was led by visual effects supervisor Paul Franklin of London-based Double Negative ("D-Neg"), an accomplished visual effects house that has been working closely with Nolan since *Batman Begins*. They were already up and running with *Interstellar* research and development even before officially coming onto the production in May 2013, way ahead of the principal photography that would begin in early August. Unlike the typical CGI (computer-generated imagery) blockbuster that might have 1,500 or more visual effects shots, *Interstellar* seems quaintly downsized—Franklin estimates their work at around 695 shots. "You'd think a film about environmental collapse and space travel, black holes and wormholes and time travel would be dripping with visual effects," Franklin says. "But this comes back to Chris's philosophy of, 'Let's try to do this for real and see how far we can go.' We use visual effects to bridge those moments we wouldn't be able to film."

ABOVE LEFT AND RIGHT The lander's maneuvers were meticulously storyboarded to ensure it moved in a manner that was both believable and dynamic. **OPPOSITE** Concept art of the lander's underside illustrates the level of detail that went into designing the vehicle.

THE CAST

Casting began in early 2013, the key role being that of frustrated pilot and reluctant farmer Cooper. Nolan was still working on the screenplay when Goldberg suggested Matthew McConaughey. "There were so many great parts, but you needed that one guy," Goldberg recalls. "It popped in my mind: 'What about, McConaughey?' It grew in Chris's mind as he was writing and when you meet the guy he kind of *is* Cooper."

McConaughey, who a year later would win the Best Actor Oscar® for *Dallas Buyers Club*, agreed to play the part. "We were thrilled when Matthew responded to the material, and he was the first role we cast," Thomas recalls. "I think it's important to cast that linchpin first. Once we knew who would play Cooper, it definitely informed our choices in terms of the other actors. From there it all came together quite quickly. Every role, small or large, was filled by actors at the top of their game. We were incredibly lucky."

The chosen ensemble soon included Nolan production veterans Sir Michael Caine, as NASA's Professor Brand, and Anne Hathaway, as his daughter, the science-minded Brand, who joins the interstellar expedition. "There's relaxation and efficiency on a Chris Nolan set," says Caine. "You never get the temperamental [actors] who won't come out of their motor home for an hour, and all that. I did a movie with John Huston and one day I asked, 'John, what's the art of direction?' He went, 'Casting. If you cast it right you haven't got a problem.' And that is Chris. He casts perfectly."

John Lithgow, who plays Donald, Cooper's father-in-law, recalls his first reading of the script: "What was extraordinary was it was so infused with emotion, with the deep fears, anxieties, and attachments of a small family. It was one of the most emotional scripts I've ever read. I was reading it on an airplane, and at the end of it I had the script in my lap and was audibly sobbing. People were looking at me like, 'Is he all right?' You don't expect that from a sci-fi movie."

In addition to John Lithgow as the grandfather, the family includes Cooper's daughter, Murph, who ages across the storyline as decades pass and her father remains on

OPPOSITE Matthew McConaughey's Cooper prepares for a journey into deep space. **TOP RIGHT** Professor Brand's daughter (Anne Hathaway), a scientist, will also join the crew of the *Endurance*. **BOTTOM RIGHT** NASA's Professor Brand (Michael Caine).

his interstellar voyage. First introduced as a ten-year old girl played by Mackenzie Foy, the adult Murph is played by Jessica Chastain, with Ellen Burstyn making a later appearance as the older Murph.

"Before we started filming, I hung out with Mackenzie a little bit and we talked about the character," says Chastain. "We talked about what might drive her and certain things we could do to mirror each other. I was really happy to share this role with her and Ellen. I couldn't be in better company."

Cooper's son, Tom, is played at fifteen years by Timothée Chalamet, with Casey Affleck in the role during his father's interstellar mission. In addition to Cooper and Brand, the NASA mission's crew includes Doyle, played by Wes Bentley, and Romilly played by David Gyasi. Also appearing is Topher Grace as Getty.

In an uncredited and unpublicized cameo, Matt Damon plays the enigmatic Dr. Mann who led the Lazarus Mission and inhabits one of the planets that Cooper and his team visit. "Our idea was that when the audience first sees Dr. Mann emerge from his cryobed, it's a big moment in the film," says Emma Thomas. "He is *Interstellar's* Colonel Kurtz. We needed an actor who could live up to the role. And Matt Damon agreed to come and have fun with us for a couple of weeks."

OPPOSITE (CLOCKWISE FROM BOTTOM): The family left behind: Donald (John Lithgow), Tom at 15 (Timothée Chalamet), and as a man (Casey Affleck). **BELOW** Young Murph played by newcomer Mackenzie Foy.

“I was really happy to share this role with [Mackenzie] and Ellen. I couldn’t be in better company.”

ABOVE The adult Murph played by Jessica Chastain. **OPPOSITE (CLOCKWISE FROM TOP)** Wes Bentley as *Endurance* crew member Doyle, Topher Grace as Getty, and David Gyasi as Romilly, another member of the *Endurance*’s intrepid team.

THE PRODUCTION TEAM

The *Interstellar* team included frequent Nolan collaborator Nilo Otero, who, as first assistant director, was involved with scouting, scheduling, and the daily logistics of making the film. He notes that although every Christopher Nolan film is different, *Interstellar* posed special challenges. "The goals were the same, but the game was different," Otero says. "Once you get off the farm there's the utterly alien and unfamiliar quality of most of the film—there's even an isolated feeling to the spacesuits. It's a science fiction movie, so absolutely everything has to be created, and it's all up for grabs. And when you do science fiction, there are more questions because there's almost no baseline, no yardstick for reality. It just makes for a relationship between the director and the actors where [Christopher Nolan] has to deliver their world to them."

In the process of putting the *Interstellar* crew together, Nolan and Thomas invited cinematographer Hoyte Van Hoytema—whose recent credits include *Her* and *Tinker Tailor Soldier Spy*—to fly to Los Angeles for a meeting.

"When Chris showed an interest in meeting with me, I didn't have to think twice," says Hoytema. "I knew nothing of the project, but I'm much more interested in the director than the script, because I think a good director can do magic with even a lesser script. I think Chris's films are complete on many different levels, extremely intelligent and sensitive. There is also an aura of the playfulness you have in smaller films that he carries into big productions."

That initial meeting went to the next step of Hoytema being handed the script. "When you look at a script, you're trying to develop a [visual] language," Hoytema explains. "Every layer in this film happens from Cooper's emotional point of view, so we didn't want to invent concepts or looks to separate [Earth and the interstellar voyage]; they are different enough already. Chris and I thought we should be consistent in our storytelling and tactile about it, as much as we could."

Also joining the crew was film editor Lee Smith, whose earlier credits include *The Truman Show* and *Master and Commander: The Far Side of the World*. *Interstellar* would

LEFT During the filming of an action sequence on a vertically orientated set, cast members are maneuvered on wires to simulate zero-g conditions.

be his sixth Nolan production. While noting how different each film can be, Smith says the editing was always an "organic process" of shaping the footage, from the first day of filming. "By now [Chris and I] have a lot of shorthand; the process is fairly well honed," Smith reflects. "At the start, you don't know what the film will be. Once the pressures of the shoot are over, it's sifting through the material, honing the performances. You strip it down and rebuild it. That's the process of editing."

The signature Nolan style—in film terms a "practical" approach—largely fell to the special effects department led by Scott R. Fisher, whose career extends from *Titanic* and *Terminator 2: Judgment Day* to Nolan's *Inception* and *The Dark Knight Rises*. While the term *visual effects* applies to the digital realm, *special effects* is the process of creating practical, in-camera effects, from explosions to wire work. "Chris looks at everything as a practical effect first; he wants what you have right there on set to drive the visual effect," says Fisher. "This includes even things you don't normally think of as a practical effect anymore, because they can now do it so easily with CGI."

Among the Nolan production regulars was George Cottle, who was making what he calls a "natural progression" from stunt performer to *Interstellar* stunt coordinator. For Cottle and his team, the biggest challenge was simulating zero-gravity conditions in space. "I finished the last Batman film and when this opportunity arose, I jumped at it," he says. "Everybody is aware Chris likes to get as much as he can in-camera, so I knew that although this was a space movie, there'd be no hiding behind CGI."

The makeup team led by Luisa Abel—who previously worked on *Inception* and *The Dark Knight Rises*—included Jay Wejebe and Kentaro Yano. "At the start we discussed with Chris how to make each character real for the audience," says Abel. "The look could not seem randomly designed, but had to make sense for what the characters were going through. We had this dust bowl Earth and a voyage to the stars, and there had to be a separate look for each character who undertook that voyage."

Mary Zophres, a costume designer and veteran of many Coen Brothers films, was new to the Nolan team and

was hired following an informal chat. In her initial meeting with Nolan and Thomas, before knowing anything about the story, the filmmakers told her there would be some "special effects costuming." Zophres worked on *Iron Man 2*, but she generally had not done effects-heavy films. "They didn't use the phrase 'science fiction,' but I was totally open with it," she recalls. "Chris said, 'Do you think you have enough prep time?' This was in the beginning of April [2013] and the movie wasn't going to start shooting until that August. I said, 'Yeah, that seems like plenty of time.' I've never had that much prep time on any movie." (It was later, when embarking on the spacesuit design, that Zophres understood the scheduling concerns.)

When Zophres finally read the script, she was sold. "It was really emotional," she recalls. "There was a loveliness about the story; it didn't feel like a dystopic, horrible future. It felt like there was hope. Chris asked me, 'How do you think it should look?' I said, 'Don't even try to predict the future. It should feel timeless and wholeheartedly American.'

ABOVE Anne Hathaway on the set of the *Endurance*.
OPPOSITE Christopher Nolan lines up a shot while director of photography, Hoyte Van Hoytema, looks on.

"Chris was happy I gleaned that from my first reading of the script. He wanted the clothes to feel real and entrenched in the environment. When the script opens, you're trying to feed the planet, so it felt weird and inappropriate to try to anticipate trends or make a fashion statement. We wanted it to feel authentic. I remember us saying, over and over, 'No, that feels too sci-fi.' We said that, in particular, when we were developing the spacesuit, but also when we were dressing people [for Earth sequences]. I used the word 'timeless' a lot, nothing that felt it was from the future."

Another key newcomer was executive producer Jake Myers, who would coordinate the complex logistics of making the movie. Myers went in knowing nothing about the story, and a few minutes after reading the script met with Nolan and Thomas to discuss it. "I drew a blank; I didn't know what to tell them," he recalls. "Normally, I'll read a script, dissect it, and figure out what it's going to take to do it. But this script was unique, an emotional journey with characters in the paradigm of interstellar space. Most of this film is in places that don't exist and had to be created, found, constructed. The farm was not a place that existed naturally, either. I thought, *'How* are we going to do this?' For most directors you'd be translating those things, but from the beginning Chris had an idea of how he wanted to do this. So we started the conversation that got into it."

Nolan particularly wanted the major settings in the film, from Cooper's farm to interstellar planets, to be found locations. "It's difficult to quantify the value of going to real places and dealing with real textures," Nolan explains. "But there's a feeling you're going to get that will have a measurable impact."

Nolan had exacting specifications for Cooper's farm, which included a fully functioning farmhouse, an adjacent field where they could actually grow corn, and a view toward distant mountains. Time was a factor, as the plan was to first shoot locations in roughly chronological story order, starting with the farm and ending with soundstage work at Sony Pictures Studios. Cooper's farm had to be ready, including that field of freshly grown corn, for the start of principal photography, less than five months away.

The farm also had to reflect the spirit of the hero and the ecological ravages of a planet in peril, the truth of the terminal condition that convinces him to join the interstellar search for a new home.

"Nolan particularly wanted the major settings in the film, from Cooper's farm to interstellar planets, to be found locations."

LEFT On location in Calgary, Christopher Nolan directs actors John Lithgow, Matthew McConaughey, and Timothée Chalamet.
OPPOSITE Cooper will go to any lengths to protect his young family.

"Cooper is a salt of the earth–type, and he's also an ex–test pilot," Crowley says. "Pilots are very organized people; they're about function. Cooper likes a challenge. He's a pioneer, a man of the past, really. The foundation of our film was the idea of pioneers in space, and once you go down that path, it starts informing you about the farm, that you need to be grounded there as well."

LEFT Cooper's family finds strength and solace in one another.
TOP Cooper and his father-in-law enjoy a rare moment of reflection.
ABOVE The grown-up Murph and Tom.

CHAPTER 3: VOYAGE OF DISCOVERY

THE SEARCH FOR A FARM LOCATION was a whirlwind affair. It was mid-April 2013 when the scout team flew to the Canadian province of Alberta and drove south toward Calgary to meet Rick Sears, a cattle rancher who also grew corn, barley, and wheat as silage for his cattle feedlots. The rancher gave a tour of his land, including a high plateau with open fields that had all the items on Nolan's checklist. Over dinner, Nolan told Sears he wanted to shoot there, and the rancher agreed. The final arrangement included Sears agreeing to plant 300 acres of corn in exchange for the production paying his feeding costs. And if the crop produced enough silage for his feedlot, Sears would pay back the production.

For Jake Myers, it was an early indication as to the focus and speed of a Nolan production. "This would usually be a more drawn out thing," Myers says. "The interesting part of the process is Chris's decisiveness."

"Calgary was fantastic, because it was a big flat horizon in every direction, with a little bit of hill off at the edge and you have the Rockies off in the distance," first AD Otero explains. "It's the quintessential farm, which is what the movie's about [in the early part of the story]. It was just a beautiful location and lyrically perfect."

But it was always risky, Myers admits, "when you have to count on the elements to build your sets." As the filmmakers learned, higher elevations, cooler temperatures, and bad weather can kill a corn crop. A massive flood turned the Calgary region into a disaster zone and flooded the Cooper farm location. Although the house had not yet been built, and the plateau drained properly, the floodwaters did the corn no good, and wet, mushy ground made it difficult to work.

Cinematographer Hoyte Van Hoytema recalls arriving at the Calgary-area location with production designer Nathan Crowley when the region "was still very much under the spell of the flood. It was a rough piece of land as far as your eye could see, and we were literally standing in the middle with a model of the farmhouse in our hands. We figured out where the sun would set and the winds would come, so we placed the farm accordingly. Then we didn't go back for a long time and had to look at pictures, as construction slowly evolved and a real farm was built."

OPPOSITE The rough-hewn Cooper farmhouse was built by the production team on a rancher's property in Calgary. Like a real home, the final enclosed set was fully furnished and had electrical power.

The final Cooper farmhouse was traditional-looking, rough-hewn, and fully functioning, with complete interiors. For the filmmakers, it felt like they were at a real place, not a movie set. "It adds a lot of realism to be able to walk from the interior into the exterior without faking it," says Hoytema. "The way the sun comes around and sets, the way the light is changing all the time inside, was pivotal to giving that farm a tactile feeling, that you really were in that place."

In order to convincingly dress the Cooper family and the inhabitants of the rural surroundings, costume designer Mary Zophres spent pre-production considering the emotional touchstones she needed to match with the wardrobe. "I thought of things like, 'Where are they shopping?'" she recalls. "If everybody's a farmer, and things are not being manufactured and no clothing is being made, there wouldn't be new styles. In my mind, people are recycling clothing that has been around for fifty years. I imagined you'd go to your neighbor's barn, clothing is stacked on bales of hay, and you'd pick through, find your size, and you're wearing it."

The wardrobe was mostly bought off the rack in thrift stores and aged. Even the spacesuits, built from scratch, got roughed up. "Aging clothes involves sanding, tumbling it with rocks or spiky balls in dryers," Zophres explains. "And then a lot you put in a washing machine with dye. We found a color that gave that dust-covered feeling, so we could take a new shirt, age it properly, and it ended up looking like it had been around for fifty years. And when we flash ahead to when Jessica Chastain is in the movie, same thing. Her clothing was aged. Casey Affleck's clothing was aged. And for the part on the spaceship, the space suits were aged, too. That's the world the film lives in."

OPPOSITE The scale farmhouse model (top) from Nathan Crowley's team was almost perfectly matched in the final set (bottom).
BELOW Concept art showing the home's interior.

"It adds a lot of realism to be able to walk from the interior into the exterior without faking it."

The director initially wanted McConaughey in a leather jacket to bolster Cooper's pilot backstory, but the actor was ultimately given a work jacket, along with a classic ensemble of T-shirt and jeans. "It's all utilitarian—practical," Zophres explains. "What can get dirty, what's easy to wash? Jeans and a T-shirt made sense. Matthew is the hero of the movie and looked good in it. I also didn't want him to look like he was trying too hard. It accomplished all those things."

The iconography of Earth was the first element fully figured out in the conceptual process, Nolan explains, and it inspired the approach for the space travel side of the story. "For Earth we wanted something that could have an iconic, visually appealing character, but more in the mold of taking real world textures and creating something visually engaging," Nolan says. "It was very important to me to carry that to the rest of the film. That was one of the big challenges from a design point of view, something we talked a lot about with Nathan: 'Okay, we now know how to do this on Earth, to create a farmhouse with an interior, and clothing and dust, to create a tactile sense of the world, and you can really believe it. How do we do that

OPPOSITE It was decided to make the Cooper home a lived-in farmhouse, not a modern structure, reflecting Cooper's roots in family and tradition. **ABOVE** The farmhouse porch. Note the distant mountains, one of the director's prerequisites during the location search.

in outer space?' We started with the spaceships: 'What if we use real aircraft components, rather than make plastic versions, to try to create real switches and real things; to not use greenscreen; to use real light coming in the [spacecraft] windows.' And that started to work."

The expedition ultimately focuses on exploring two worlds, one composed of ice and the other of water. "It's always a sort of a voyage of discovery when you make a film," Crowley says. "Chris and I would get on a plane to somewhere, do a bit of research, stick [reference photos] on the wall, and then go scouting again—we had planets to find!"

OPPOSITE In Calgary, Christopher Nolan surveys the landscape while planning a shot.
ABOVE Nolan and McConaughey collaborate on a scene at the farmhouse.

"It's always a sort of a voyage of discovery when you make a film."

DISCOVERING PLANETS

Crowley and Nolan were considering beautiful landscapes in Chile and other places, until a revelation during a scout in northern England. "Chris and I ended up standing in this sort of muddy estuary and we thought, 'Hold on, maybe [the planets] should look like *this*,'" Crowley recalls. "'Maybe it shouldn't be a beautiful landscape.' It is sad to leave Earth, and the alternative is not great. Designing with Chris, you sort of discover together what feels right and what feels wrong."

"The adventure story idea of surviving in extreme circumstances is what drove our location scout," Nolan explains. "I think Nathan naturally gravitated to finding something otherworldly and spectacular, but what we rapidly started to feel is if you could believe in the tactile nature of water around you and splashing on the space helmet, for example, you could relate to it; an audience would understand that would be uncomfortable and challenging. That was more important than generic spectacle, a pretty vista or whatever. The planets are meant to be very elemental. And the reason is when people talk about the improbability and difficulties of finding another planet, they tend to ignore the extremity of life on Earth, the different climates and the narrow band human beings are able to survive in. It seemed it'd be extremely lucky to find a place anywhere in the universe that had all the different features we have on Earth, that any place they found would be the extreme of what could sustain life. It could be like the Antarctic, it could be like the Sahara. I wanted to have very clear and symbolic ideas of what each world was. The symbols I use in my scripts I tend not to analyze; they tend to be instinctive. I say, 'I know there's something that speaks to me about that.' But no matter where you go, the planets become a choice of clear extremes."

It was decided a glacier would best represent the ice planet. Nolan had shot on one in Iceland for *Batman Begins* and near another in British Columbia for *Insomnia*. For *Interstellar*, the director was initially eager to shoot on a glacier he once trekked across in Argentina, Myers recalls, but Nolan finally decided they should scout Iceland, because it might also supply a location for the water planet.

RIGHT Concept art shows the unrelentingly bleak landscape of the ice planet, one of the key locations the production team needed to find.

In Iceland, the scout team headed straight for the familiar location that had passed into local legend as the "Batman glacier." (Reportedly, the tour guide, not recognizing the director, made a point of explaining that Christopher Nolan had filmed there.) The glacier had changed since *Batman Begins*—the 2010 explosion of the volcano Eyjafjallajökull showered the white ice with fine ash. "In Iceland, the sky was heavy and overcast, the glacier was dirty," Crowley recalls. "But that could be very good for our story. You've come all this way and you're left with a very poor option for Earth."

For the water planet, Nolan wanted a seemingly endless expanse of water, two to three feet deep. Luck seemed with them—a potential location was found a fifteen-minute drive from the glacier. "There was a farmer whose kid wanted to be in film school and who was very excited to take us over his massive tracts of land," Myers recalls. "We found these weird plains next to the ocean that went on for miles. But there was only an inch or so of water. We were trying to figure how to make it deeper."

The production's Icelandic art department subsequently found another expanse of glacial melt with the desired depth; in the same general area. But the only way in was a rugged fifteen-kilometer drive down a wreck of a road that started flat and gravelly, with large plains where wild horses ran, before turning into rugged riverbeds and marshland. Myers's advance work required laying down a new road to ensure cast, crew, equipment, and pieces of the set could safely get back and forth between lodging and locations. It was a major undertaking but turned an average fifty-five-minute drive into twenty-five minutes.

"It's fun for me to go on location for the first time, because by that stage I've been living with the script for some time, but it's all been in my own mind," says Otero, who did not participate in the initial location scout. "And all of a sudden—boom. You see these physical places and your mind just starts to race. . . . You just say, 'This is absolutely, unimaginably perfect—I didn't know there was a place like this in the world.' Well, there is, and it takes a while to get there, but it's so worth it. It helps everybody conceptualizing the picture to live the fiction. And that pays off in the final film in ways that are beyond description."

OPPOSITE A global search for interstellar planet locations ranged from Argentina to England. When it was decided not to have beautiful worlds but planets characterized by harsh conditions, rugged and otherworldly Iceland became the all-purpose location.
BELOW The *Interstellar* team scouts Iceland: (*left to right*) Scott R. Fisher, Nathan Crowley, Nilo Otero, Christopher Nolan, and Paul Franklin.

THE MAGIC OF FILM

Interstellar was shot with 35mm film and also made use of IMAX cameras that utilize a 65mm film format that no digital medium matches. Nolan used IMAX cameras for certain sequences on his Batman films and planned a more ambitious use of the technology than had been attempted for a regular theatrical feature. "I think every movie we make with the IMAX camera we do new things," says Thomas. "From *The Dark Knight* to *The Dark Knight Rises*, we expanded our use of it, moving into *Interstellar*."

"The thing about IMAX, with its large negative, is that it has an incredibly detailed and sharp image," Nolan says. "It's got a lovely shallow depth of field, but then when everything is in focus there's incredible depth to the image. It can really immerse you in another world, particularly when projected using an IMAX film projector on a huge screen. It's the best imaging format there is, really, the best presentation format there is, and vastly superior to any digital format."

LEFT On the *Endurance* set, Christopher Nolan fine-tunes a shot. **OPPOSITE TOP** Nolan on location in Calgary. **OPPOSITE BOTTOM** Nolan and cinematographer Hoyte Van Hoytema work together on a shot in Murph's bedroom, the director offering some help with the special effects.

The use of IMAX cameras in traditional features has been limited by film magazines that only run several minutes, camera noise that drowns out dialogue, and the heaviness of the camera itself—sixty to seventy pounds, "about the size of a typical hotel minibar fridge," Hoytema says, laughing. But Nolan wanted the kind of immersive imagery only IMAX cameras could give him, and he planned to use it not only for the strange grandeur of interstellar worlds, but earthbound scenes where Cooper's family faces the planet's struggle. The visual effects would be largely created in the IMAX aspect ratio, what visual effects supervisor Franklin calls the "largest canvas to paint on."

COOPER'S CORN CROP

A few weeks before filming, there was a technical survey trip to all the locations, the typical walk-through for all key production personnel that included electricians, grips, riggers, and set dressers. Everything was ready at the Cooper farm—except the 300 acres of corn that suffered through the region's disastrous flood and a spell of cold weather. "The corn looked like a broccoli field," executive producer Jordan Goldberg recalls. "And we needed that ocean of corn. It was part of building scope and scale, and kind of the iconic signature of a Chris Nolan film."

But the start of filming coincided with dry and warmer weather—a happy event for the battered and withered cornfield. "When we got there to shoot, the corn had grown a couple feet, and by the end it was towering," Goldberg says. "It was pretty amazing. The guy who owned the land said it was on the edge of common sense to grow corn there, but it fit the point of the movie—Earth is running out of usable land to grow stuff. Corn is the main crop, and you're growing it in a place where you wouldn't necessarily grow corn, like the high plains, where you could see mountains in the background. That's what Calgary gave us. The farmer was surprised to see us grow as much corn as we did. He said the wind usually comes down and blows this stuff over. We got lucky."

A month after filming wrapped at the farm, the 300 acres were harvested. The silage crop yield was so plentiful that rancher Rick Sears wrote a check and paid back the production.

THESE PAGES Nolan's criteria for the farmhouse location included an adjacent field where the production could grow 300 acres of real corn—and burn it, emphasizing Earth's deepening ecological crisis.

CHAPTER 4: DYING PLANET

FROM THE START OF PRINCIPAL PHOTOGRAPHY, cinematographer Hoyte Van Hoytema embraced Nolan's preference for physical sets, real locations, and in-camera effects. "Apart from it being boring to film green-screen, as a creator you want to relate to a certain reality, and that reality influences your work," says Hoytema. "I'm not a cinematographer who says the image is going to be like this. I like to look around before I put the camera up, to dream a little bit and feel it out. I like to think of myself as working much more organically, especially with somebody like Chris, who has an eye for the elements around him that we could react to and turn into something useful. That is the advantage in keeping your situation real. You already have a world; you just have to point a camera at it and use your energy to enrich that world."

It was a world, editor Lee Smith explains, that was all in Nolan's head: "We didn't do that much pre-viz, very little storyboarding. These productions aren't for the fainthearted, but the whole film was completely mapped out in his brain. That's a rare quality."

LEFT Christopher Nolan and crew gear up for another epic dust storm shot.

FILMING

During the first week of filming at Cooper's farm, the IMAX camera was used handheld for the first time. Carrying the heavy camera on his shoulder was "torture" that first week, Hoytema admits, but as filming progressed he got stronger and they worked out an efficient system. "It was heavy, but, thank god, the magazines are very short, so you never have to hold it longer than two minutes at a time," Hoytema says. "At 'roll camera,' Ryan [Monroe], my dolly grip, would put it on my shoulder and [when we cut] he would pull it off. He had all sorts of ways of balancing it, so we found a system. We then knew we could take that camera and get in there and run with the actors. I think 70 percent of all our IMAX shots are handheld. IMAX is very much a physical experience; you're really in the picture. We used it whenever we could."

Although traditionally the noisy IMAX camera is not used to shoot dialogue, in *Interstellar* it was used to capture some intimate scenes. This included long dialogue sequences with the interstellar voyagers in their helmets and spacesuits—by a happy accident it was discovered that the helmet's built-in microphones bypassed outside noise. "We ended up shooting much more dialogue with the IMAX than any other production I know of, because of these helmets," Hoytema says. "There's a long section of dialogue between the actors walking up and down the glacier, so we could follow them and record. In Iceland we probably shot 70 percent of everything on IMAX."

"Traditionally, people use IMAX for vistas, or when you want to emerge into something," Hoytema continues. "But a face can be a vista, and close-ups can work beautifully on a big format. I fell in love with the medium, with this beautiful feeling the lenses give with a short depth of field. Chris knew this, of course, because he had been using the format with Wally Pfister, the cinematographer on a number of Nolan films, including *The Dark Knight Rises*. I was very happy to take it one step further and make the IMAX a handheld workhorse camera."

Both large and standard film formats captured the grit and rawness of the Cooper family's struggle for survival. "[In the story] it's very hard to be a farmer," says actor Casey Affleck, who plays the older Tom. "Things are getting worse, and there's no end in sight. But, as Chris pointed out, if there's a bad year, a lot of farmers will always have hope that next year things are going to be better. I think that's a big part of what drives my character."

DUST STORMS

Jonah Nolan's original screenplay saw blight ruining the world's crops, but the director ultimately illustrated the planet's terminal condition through a plague of dust storms. "I very much liked the first act of Jonah's original screenplay and the world it created, but blight itself, although extraordinarily threatening and a wonderful apocalyptic scenario, is a little hard to present visually," Nolan explains. "I wanted to make the threat more palpable and immediate. While researching the idea of agricultural disasters, I watched Ken Burns's documentary about the Dust Bowl. I was struck by the extraordinary images and stories of these mammoth dust storms; they truly are like science fiction. We actually toned that imagery down because no one would believe it, particularly presented in a science fiction context. But that was what led to the idea of incorporating the historic reality of the Dust Bowl. I wanted to ground the story, and [massive dust storms] were frightening but seemed implausible— could this really happen? The answer is it *has* happened, so absolutely it could happen. If you can make that point to an audience—and I think they'll feel that from the authenticity of that imagery—the whole thing becomes more relatable and also much more frightening."

"The dust storms were very important to Chris, this apocalyptic parallel back to the old Depression Dust Bowl," Nilo Otero explains. "It's something that exists in people's

OPPOSITE TOP AND BOTTOM Hoyte Van Hoytema shot with large-format IMAX and 35-millimeter cameras. **LEFT** With a camera mounted on a truck, the production team shoots a dust storm scene.

minds, if not as a memory then certainly as an image. Therefore it was incumbent on us to come up with this overpowering sensation of a wall of dust across this vast horizon in Western Canada. It's a magnificent stage [on which to unleash] a dust storm, to go from infinite vision to a claustrophobic opaqueness. And to do that, it can't look like a CG fog rolling in; it's got to be real. And to do it for real we drew on the skills of our amazing special effects team."

The dust itself was biodegradable cardboard, finely ground. "They actually use it as a food additive because it's filler," special effects coordinator Scott R. Fisher reveals. "It's funny, the safety guy on one of our first production meetings said, 'This is used in cheese. You guys have all eaten this!'" The dust product came in 30-cubic-foot bags that the special effects team hooked to air compressors—"air movers," Fisher calls them—with a tube sucking up the particles and shooting them into the stream of large blowing fans, the biggest being six-foot blades capable of spinning at 500 horsepower.

"Coming from small movies, I was wondering, 'How do you create a dust storm?'" Hoytema recalls. "Well, you just do it! You're covered from head to toe in dust, people have handkerchiefs in front of their mouths or dust masks and protective glasses. I was operating an IMAX camera on my shoulder through that dust, struggling with the wind. You don't worry about dropping it—the first priority is to get the shot right! And the camera has to be serviced all the time because dust gets everywhere. You always have one assigned technician. In the hotel room at night, the technician would rebuild or exchange the motor boards or engines inside the camera. There was constant service on those cameras."

There were different types of dust storms, including an "engulfing" effect used for two scenes in which Cooper gets caught in the tempest while driving his truck—once going into town, the other at his farmhouse. "Those are the hardest because you have a moving object and you have to sort of move your storm as you go," Fisher explains. "[Christopher Nolan] really wanted it to feel ominous, getting closer and closer and then overtaking. We had some fans driven on trailers, so they could be pacing with [McConaughey] and putting out the [fake dust] at the right time. You have a little control, but you really have to play the wind once it starts coming on. Chris understood that."

One of the biggest storms was in Fort Macleod, an Alberta stand-in for the small town near Cooper's farm. Fisher's team had about ten fans they could flip from one end of the main street to the other, and they added fans on traveling rigs that moved with the action, and even tucked some in adjacent alleyways.

"Near the end of the day at Fort Macleod, I was standing behind these massive fans that are so loud you had to wear ear protection," Jordan Goldberg recalls. "There were five or six of them at the end of the street, blowing dust to where the scene was being shot. The sun was going down to the point where the dust encased the sun and darkened the street. In accounts of living through the Dust Bowl, they'd say these storms would blanket the sun, and day became night. I saw that happen."

The Dust Bowl was also recalled in a refugee scene shot some four hours from Calgary, where between 200 and 300 people went through costume, hair, and makeup. For the refugee wardrobe, costume designer Mary Zophres wanted cotton, because it looked more realistic. "I didn't want a bunch of refugees in polyester," she says. "I didn't want it to look like the future, but I also didn't want it to look like we were in 2013. In general it was solids and layers because there was so much wind and dust that people needed to layer their bodies as protection. As refugees, they've left with the clothes on their backs, so they probably threw on another layer or two. It was about keeping it real. You wanted to feel sorrow and sympathy for these people. You see them walking, some are in old cars packed with stuff. It was all covered with dust, there was so much dust being blown."

BELOW Director and star take a breather. **OPPOSITE** Special effects coordinator Scott R. Fisher's team fanned the film's ferocious dust storms.

INTERSTELLAR MISSION

"Chris is a terrific storyteller and you have this sense that everything he shoots he'll use; there's no extraneous work," says John Lithgow. "The other thing I find thrilling is he loves to work from reality. When they say there'll be a dust storm, or they'll be burning crops, you figure we're going to be looking at an empty landscape, we'll have to pretend, and they'll put it in later. No! You turn around, and, my god, there's an entire field burning!"

"Story-wise, the Earth is fading," Scott R. Fisher notes. "Cooper has to burn [his cornfield], but it's so dry that some of the fires get out of control. As with the dust storms, the mandate was 'As big as you can get in camera.' Chris wanted a *massive* fire."

The practical effects team laid down classic fire bars with liquid propane. Fisher had water trucks with fire hoses ready, just in case, but they could adjust the flame level. "We could always control it; it would burn the area right where our piping was," Fisher says. "We'd keep moving our fire line back as the corn kept burning away. Everything is going to hell—dust storms, crops burning, people getting out."

Against this backdrop of accelerating decay, Cooper discovers the underground NASA facility where the forgotten space agency has secretly been developing an escape plan. Professor Brand explains to Cooper that almost a half century ago a wormhole was discovered near Saturn. One-way manned trips through the wormhole into another galaxy—NASA's so-called Lazarus Missions—led to signals identifying potentially habitable worlds being received ten years ago. With that hope, NASA embarked on a decade-long project to build a modular spacecraft that could be used to find the best planet for colonization. The prospective crew, including Professor Brand's daughter, has trained only on simulators, but Cooper has flown for real—will he lead the mission?

Cooper faces the anguished decision of leaving family and home. But with the specter of a doomed planet, he realizes the mission is humankind's best hope—and his destiny. "[Cooper] has been widowed for ten years; he's going to do his duty and take care of his kids, as any good father would do," McConaughey notes. "But he's a dreamer more than a pragmatist. The trip is where he becomes a man of invention. He's at home in the cockpit in space, not on the tractor at the farm."

RIGHT Concept art details NASA's vast underground launch site.

CHAPTER 5: ENDURANCE

INTERSTELLAR'S PRE-PRODUCTION RESEARCH included a visit to the space shuttle *Endeavour*. In 2012, after 122 million miles in orbital flight, the *Endeavour* was put out to pasture with a farewell flyover across the California sky, transported atop a Boeing 747, to its new home at the California Science Center in Los Angeles. The production also visited Space Exploration Technologies Corporation, otherwise known as SpaceX, a private aerospace company headquartered in Hawthorne, California, founded in 2002 by Tesla Motors co-founder Elon Musk. (SpaceX has won a number of NASA contracts and is working on reducing space transportation costs, with an eye on the eventual colonization of Mars.)[8]

"Elon is a modern day pioneer," says Emma Thomas. "When we went to look around SpaceX, they had one of their craft in space. I've always been fascinated by space—as a kid, I remember watching space shuttle launches [on TV], and I love watching the IMAX films that have been made in outer space. So, I wondered what a control room would look like today. There is the cliché of the old NASA control rooms with technicians standing around in suits, smoking cigarettes. The SpaceX control room looked extremely different. It was all young guys in hoodies with big Apple Macs."

MADE IN SPACE

The research resulted in a massive modular ship the production called the USS *Endurance*. The *Endurance* features a circular configuration so it can rotate and simulate gravity. Twelve pod modules linked by airlocks form the ring, with a tube extending to the central area that houses four docking points for the two landers, workhorse cargo ships designed to take equipment down to the planet, and two Rangers, an exploratory craft. "Four of the modules are engines, four are for permanent living and operations—cockpit, cryobeds, habitat—and the last four can be detached and landed on a planet by the lander to provide essentials for the start of a colony," Crowley explains.

"For the Ranger think sports car; for the lander think truck," says Nilo Otero. "They were constructed in their entirety. They would sit on a hydraulic rig that could dance

OPPOSITE Concept art reveals the USS *Endurance*'s elaborate yet practical design.

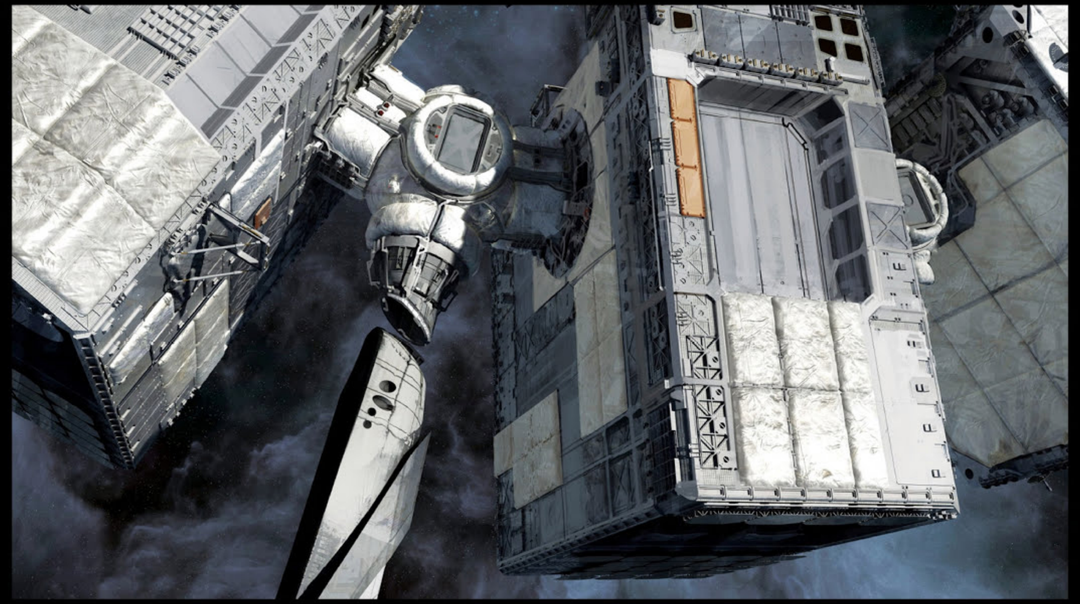
them in any of a number of positions. And we had interiors for each of the spaceships that were also on hydraulic rigs that enabled them to move. Again, this put the actors in the physical reality of what was going on in the fiction and helped them live the role."

"The idea is there would be standardized modules assembled over time in low-Earth orbit," Nolan adds. "[NASA] has just about used up everything they've got, so they've put everything remaining into this one arrangement of materials and assets, this ship that could sustain life for years and years."

"[The *Endurance*] needed to be utilitarian, every space filled."

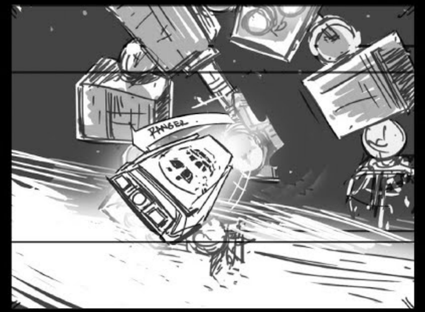
There would be no "space decadence" inside, Nathan Crowley explains, no big rooms or empty spaces. The interior was about functionality and "density," with every square inch filled and the set itself enclosed, with airlocks and connecting corridors. In that respect, the *Endurance* emulates another craft designed to venture into deadly, inhospitable territory—the cramped quarters of a submarine in the ocean's crushing depths. "We shouldn't be in space, so this is the thing that's keeping you alive," Crowley says. "Looking at the *Endeavour* in L.A., we realized that everything had a function. You have to take everything with you, so we wanted to enhance the danger of that. It needed to be utilitarian, every space filled. It's all about storage. Our theory of confined spaces, and the idea that you couldn't waste space, grew and grew—everything became like a mosaic tiling of NASA equipment. We started with this theory they'd been building this in space, using a mishmash of older and newer material. We ended up collecting an enormous warehouse of stuff. For padding alone, we started with 700 to 800 yards and had to double that! It just never seemed to stop. There was always some bit of space to fill."

LEFT Concept art shows the design of the *Endurance*, which was inspired by research into the International Space Station and space shuttle programs. The modular design was deemed practical for storage and carrying capacity, as well as for isolating areas that might become damaged or compromised.



The production built the *Endurance*, among other major sets, on the Sony soundstages in Culver City, California, the studio formerly owned by MGM during Hollywood's Golden Age. Stage 30, home to the *Endurance*, one of the biggest soundstages in Hollywood, was where Nolan built his Batcave for *The Dark Knight Rises*. For the *Endurance*, Nolan chose to construct three sections: habitat living quarters on one end, an interchangeable lab and cryobed on the other end, and a command pod in the middle. The three pods sat on a massive, 160-foot hydraulic gimbal built by special effects and dubbed the "seesaw" or "horseshoe" rig.

"It would have been too big to build the whole ring," says cinematographer Hoytema. "The gimbal allowed us to put each of the pods at ground level for filming. That left one pod at a forty-five-degree angle, so you couldn't really



film there, but inside [the ground level pod] you always had views of that angle of the adjacent pod going up. You would always be aware you were in a round shape."

Special effects coordinator Scott R. Fisher notes that the ship's automated features fell into his department's practical world—there were airlocks to open, landers and Rangers that needed to dock with the main ship, cryobeds that had to move up or down, and chairs that had to operate in different positions. Some functions were manually controlled, while docking and other complex sequences required "motion control," a computer programming system developed to fly spacecraft models and other elements for the original Star Wars trilogy. "When timing and tolerances are tight, you have to program it," Fisher explains. "[Using motion control] we can rehearse, set it up, and program moves to be repeatable. It can't be hit or miss or you lose production time."

"Films of this scope, with all the different toys and construction that goes into a scene, can make an actor feel constricted—you have to hit a certain mark, speak at a certain time," adds Matthew McConaughey, in tribute to the work of the craftsmen who brought the world of *Interstellar* to life. "But I didn't feel the walls crushing in. When I was in a scene it felt free and intimate."

OPPOSITE TOP AND BELOW The *Endurance* design includes airlocks connecting the ring of modules. **OPPOSITE BOTTOM RIGHT A** storyboard shows the Ranger interacting with the docking mechanism on the *Endurance*.

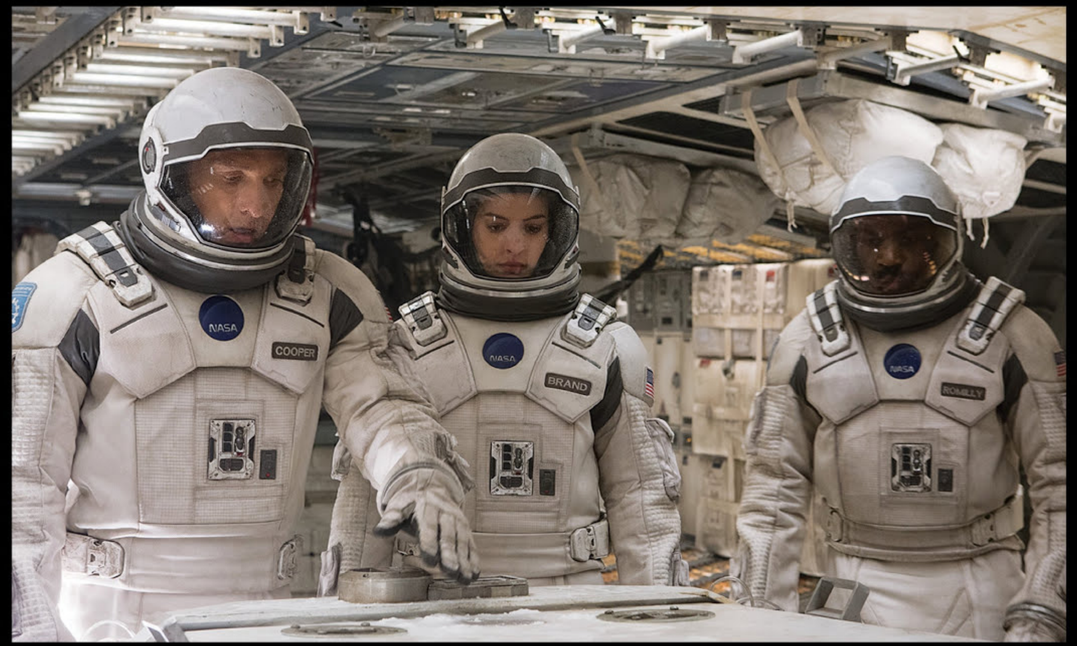
TOP Anne Hathaway emerges from one of the cryobeds built in the cryolab section of the *Endurance* set.
ABOVE The crew of the *Endurance* discuss their plan of action in the Command pod.
OPPOSITE Concept art shows the interior of an airlock shaft aboard the *Endurance*.

SUITING UP FOR SPACE

The late astronaut Wally Schirra, a storied veteran of the Mercury, Gemini, and Apollo space programs, once summed up the dangers of space: "It's a hostile environment, and it's trying to kill you."[9] For astronauts in outer space, a spacesuit and helmet are all that stand between survival and oblivion.

A real spacesuit—an "extravehicular mobility unit"—has by necessity been complex and cumbersome. A circa-'90s suit, for example, was made of parts from some eighty different firms, weighed 250 pounds on Earth, and took fifteen minutes to get into.[10] "If you look at an Apollo-era suit, there's nothing shiny and new, it's kind of clunky and awkward," Zophres notes. "To keep a person protected in space, there are twenty layers of material between the outer and inner layer."

BELOW For costume designer Mary Zophres, the astronauts' ensemble was the biggest costume challenge.
OPPOSITE TOP The spacesuits required the production's own version of a NASA "portable life support system" as seen in this concept illustration.
OPPOSITE BOTTOM Christopher Nolan inspects the all-important space helmet.



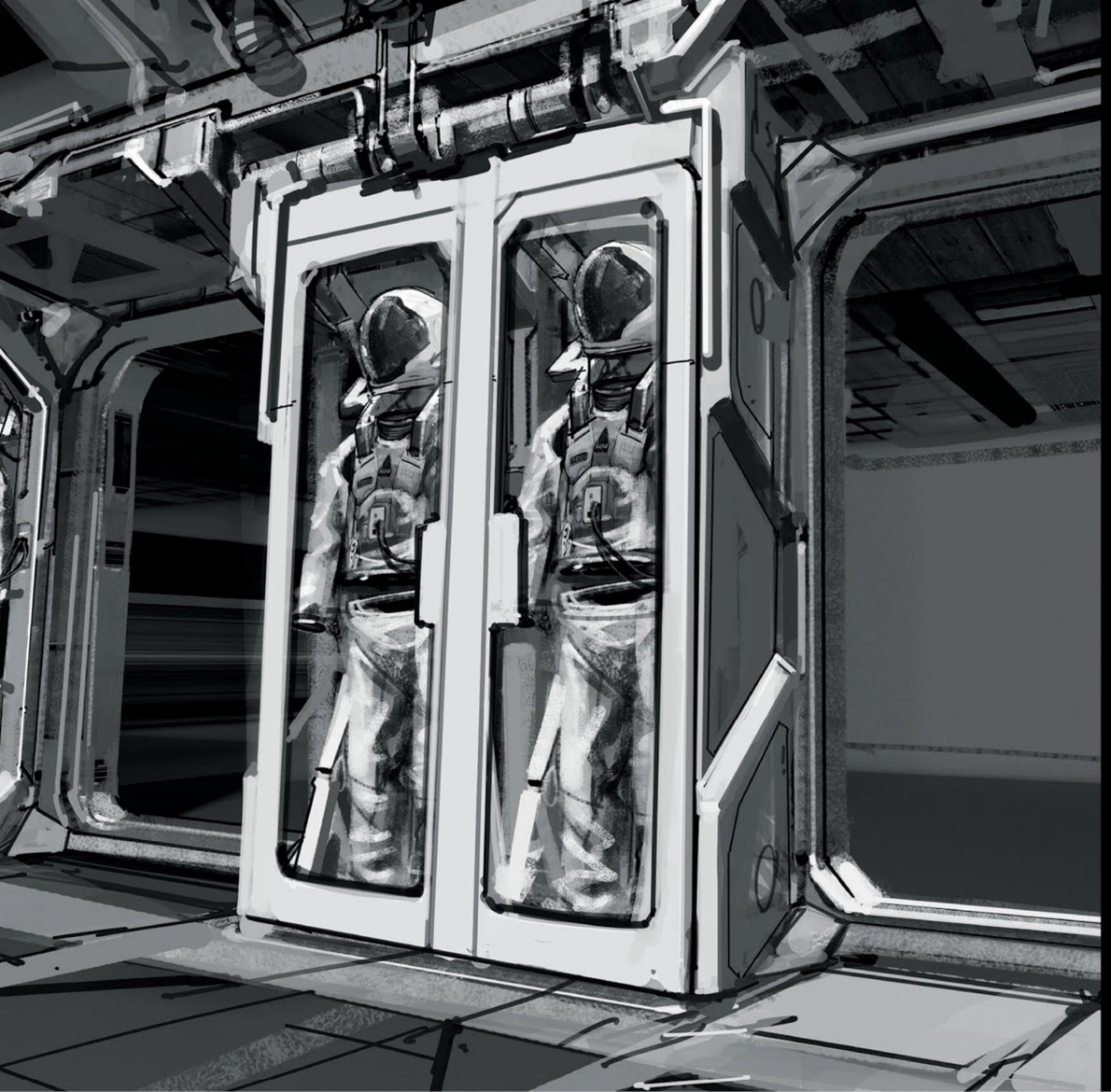
"There can't be anything more isolating than being inside a spacesuit where you carry your own world with you," Nilo Otero reflects. "And it was important that we maintained the feeling of being in that bubble."

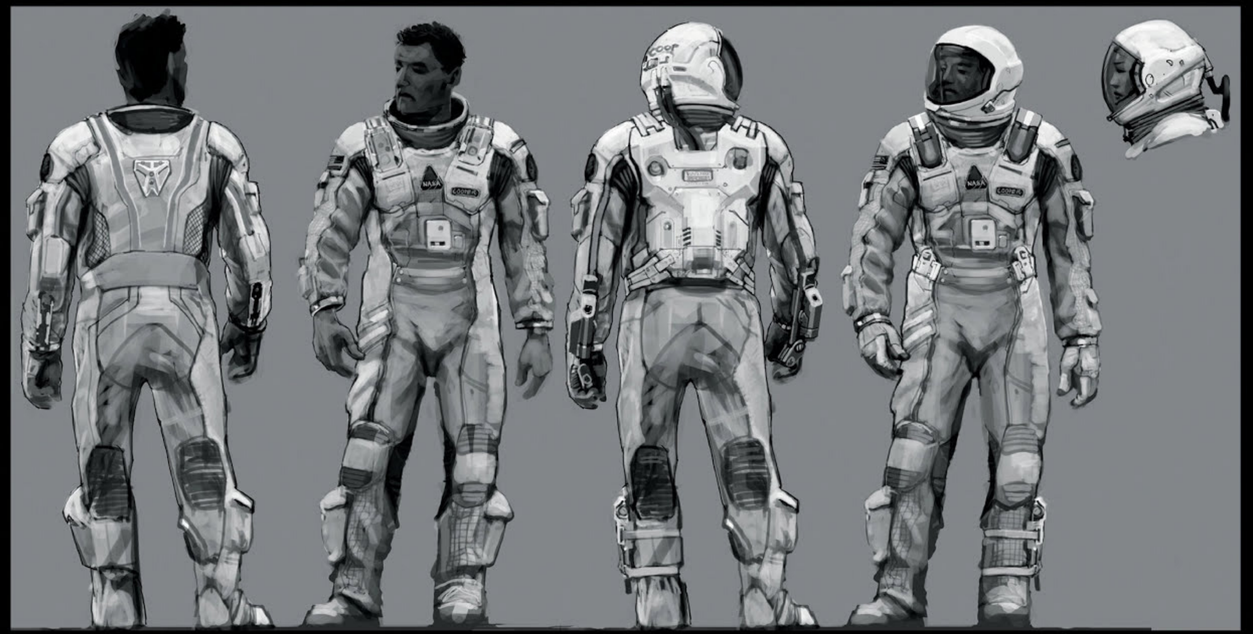
The *Interstellar* suit required its own version of a "portable life support system"—the backpack that provides oxygen, cooling air, and communications—that snapped on at the waist and shoulders. To make the suit look pressurized, there were leg straps at the bottom of the pants and neck and wrist rings. "We wanted our spacesuits to be functional, because NASA is functional," Zophres explains. "And we wanted to make them white because in the imagination of everybody who thinks about outer space, an astronaut wears a white spacesuit."

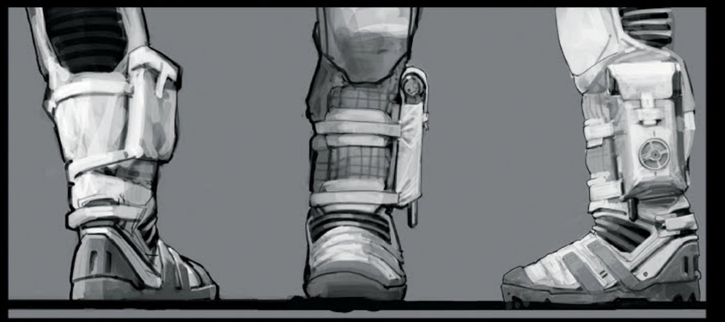
> "For astronauts in outer space, a spacesuit and helmet are all that stand between survival and oblivion."

Making the spacesuits was a long-distance sprint to the finish line. Having started work in April, by the first of May, the costume department had done its research and was building prototypes; by July they were camera testing, with shooting due to begin in August. Just getting the fit of the suit was a two-week endeavor, Zophres recalls. She estimates spacesuits are seen in about 60 percent of the film, so it was decided to avoid a real suit's inherent bulk, or "puffiness," as she puts it. "We kind of landed in the middle, somewhere between the Mercury and Apollo missions, with utilitarian details reminiscent of what you'd find on a real suit. I always asked, 'Is [a detail] there for a reason or just decoration?' If it was decoration, I scrapped it and went to something else."

The costume designer had some material from a current spacesuit for reference, a fireproofed nylon. She wanted a highly textured nylon, minus the fireproofing that would have added a coarser texture that, when rubbed







THESE PAGES Concept art shows a variety of elements that were key to the final spacesuit designs. Costume designer Mary Zophres wanted to avoid the inherent puffiness of real spacesuits. The final design landed somewhere between the suits of the Mercury and Apollo space programs.

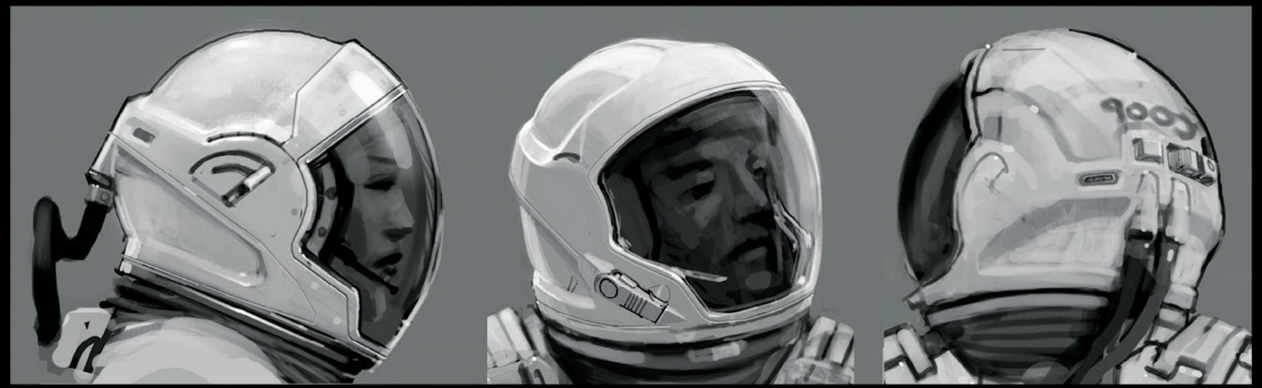
or moved, would be too noisy for filming. At a Los Angeles fabric store, the best match for a prominent horizontal and vertical weave had just come in from Italy. "That's what makes a fabric—the weave," Zophres explains. "If you look at a nylon backpack, where you can see the grain of the fabric, it has a vivid texture. That's very appealing to me, giving things texture so the surface is not flat and boring. The texture grabs on when you age the material; it's not smooth, glossy, or slippery."

Zophres hailed the special effects department for creating the various features for this prop-heavy costume, including the forearm thrusters designed to look like they were giving bursts of propulsion. "We had solenoids that used nitrous oxide for the jet vapor," Fisher explains. "The kinds of thrusters we used were based on the shot. Some thrusters were remote-controlled. For close-ups we were able to operate them off-camera using cables running down the leg [of the spacesuit]." When the effect was not needed, suits fitted with regular plastic, nonfunctioning thrusters were available.

The helmet was a challenge in itself. "Chris was experienced with the proportion of heads and shoulders from the Batman films and did not want a huge helmet," Zophres says. "He still wanted it to be a heroic person inside the spacesuit. We kept scaling it as small as we possibly could, basing it on the Mercury helmet in terms of size. You had to be able to breathe in it, and that was scary, the thing that made me the most nervous. If you didn't get it right, your actors could pass out, someone could get hurt. So we had to work a fan in and make sure we were getting oxygen into their helmets."

Prototype helmet shapes were created in miniature using a 3-D printer, one of four that Nathan Crowley's art department used to create and test designs in-house. Crowley likens the device to an icing squeezer, only the nozzle lays down plastic based on the desired specifications. "It builds up on a flat plate—you *grow* it, in a sense," he explains. "The layers keep building up over seven to eight hours."

"Even two years ago, a model maker would have produced the helmet by carving and casting it," Zophres notes. "It's totally new technology now. Once we got Chris's



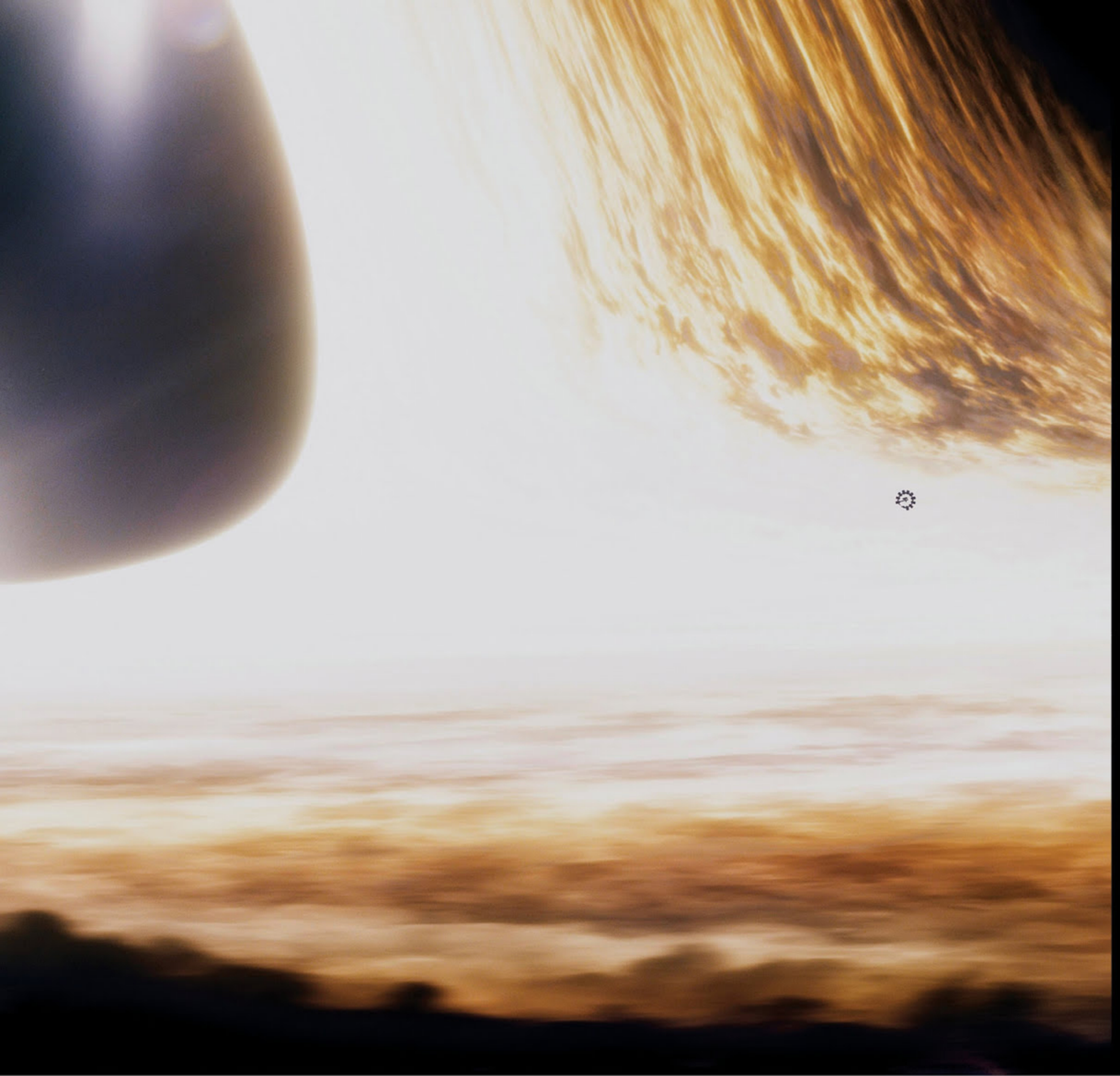
ABOVE AND OPPOSITE Concept art for the spacesuit helmet (*opposite top*) formed the basis for the finished piece, as worn here by Anne Hathaway (*opposite bottom*).

approval on our 3-D model, we split it into different pattern pieces and modeled it. It was super complicated—the helmet has at least a dozen parts."

During her first fitting for the spacesuit, Anne Hathaway was surprised at how heavy it was. "The suit took some getting used to," she says "The suit itself was fine, but once you put on the backpack, and the helmet, and the gloves, it was hard to breathe and could get very hot, especially when you were strapped into the rigs for the zero-g stuff. We had to have air blowing in our faces so the faceplates wouldn't fog up, but that meant wearing a fifteen-pound [backpack] to hold the motor that allowed the air to flow."

It was during the spacesuit fitting that Hathaway realized she had to get as tough as the suit. "I got on my phone and called a guy I know who's an ex-Navy SEAL and I said, 'You need to get in the gym with me and toughen me up.' It was something you had to work really, really hard to be able to wear. But as Matthew and I kept saying to each other, 'This is tough, but we look cool!'"

"The suit itself was fine, but once you put on the backpack, and the helmet, and the gloves, it was hard to breathe and could get very hot, especially when you were strapped into the rigs for the zero-g stuff."



PART TWO

INTERSTELLAR VOYAGE

CHAPTER 6: TO THE STARS

THE REALISM OF THE *ENDURANCE* allowed the actors to subsume themselves in the illusion of a modular spacecraft traveling to another galaxy. "When we built the spaceships, we kept them claustrophobic," Nolan says. "We didn't 'fly' any walls; we just made the camera crew crush in there with the actors, and closed the door behind everybody."

"Walking onto these sets lent a degree of credibility and an emotional response," Hathaway notes. "All of it allowed you to lose yourself a bit more and turn off that little voice in your head when you're doing greenscreen and wondering, 'Am I doing this right? Am I on the same page as everybody?' It looked like a spaceship designed by humans. It sounds silly, but there was a lot of Velcro on this ship that astronauts really do use, but you don't see in a lot of sci-fi films. The *Endurance* becomes our home, but there's nothing cozy there. Everything is practical, everything has a use. You just imagine what that would do to you over years and years and how that would make you a bit weary. Things have been used, there's dust—you get the sense there's a finite amount of everything, which grounds the film and makes certain moments truly terrifying."

Hathaway recalls how the heavy spacesuit contributed to the emotional pitch of a scene where Brand argues with Cooper. "I started to hyperventilate because the suit was so claustrophobic; I had to get out of it," she recalls. "Chris liked that, so that became a choice my character was making. You could open yourself to the reality of everything and it wound up serving you very well."

The confined *Endurance* set inspired not only the actors, but also the filmmakers. "The feeling of claustrophobia inside this tin can was essential," Hoytema says. "We gave ourselves the rule that we had to technically adapt ourselves to be with the actors in that space. Of course, if you throw an IMAX camera in the mix it gets extra challenging. But the IMAX camera was sent to space. We felt that working with these wide-angle lenses added to that reality, that your camera is in the space with the actors. We did everything to make our shooting situation less comfortable, but it added to the credibility of the images."

OPPOSITE The cast of *Interstellar* underwent physical training to help them endure the rigors of the wirework techniques used to simulate zero-g.

"I remember talking early on with Hoyte about how we had a visual responsibility because people have actually seen a lot of film from space that NASA has provided," Otero says. "That means that people have a subconscious visual vocabulary and set of expectations."

The focus on realism even extended to the actors' makeup. Back on Earth, Cooper's skin tone showed the effects of sun, wind, and dust, but the makeup for astronaut Cooper reflected his confinement in the ship, as well as his emotional state. "We felt he should definitely look paler, so you get the emotional journey going on with him," makeup head Luisa Abel says. "He's been ripped away from his family, even though it's for a good reason. There are subtle ways to change somebody's look, breaking someone's eyes down so they look tired or worried or teary, putting a distress in the face that should not be obvious to an audience."

BELOW Despite their different backgrounds, Cooper and Brand form a strong bond during the tough mission.
OPPOSITE The *Interstellar* cast and crew had to cram themselves into the realistically tight spaces that formed the interior of the Ranger.

THESE PAGES The *Endurance* was "home," but its tight quarters have an ominous, claustrophobic feel that takes its toll on the crew, including Doyle (*top*), Romilly (*bottom*) and Cooper (*right*).

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ROBOTS

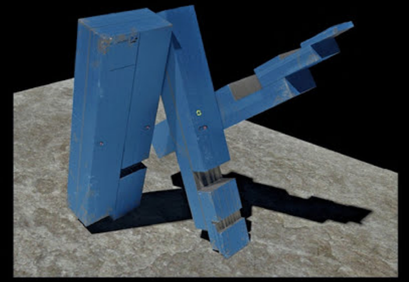
The *Endurance* is equipped with two robots, TARS and CASE, their design the opposite of the typical humanoid automaton. "When you see the robots, there are very few features that would give them away as robots," says special effects coordinator Scott R. Fisher. "They are service robots, and can pilot the ship if needed. They're utilitarian—no flash, no bling."

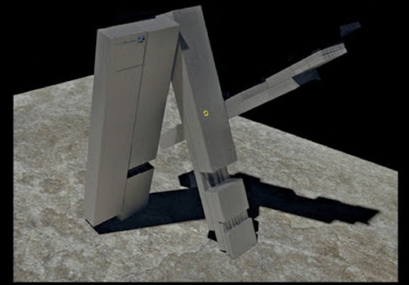
Nathan Crowley recalls Nolan stripping away the popular notion of robots to a basic articulated form, referencing planks of balsa wood and even lollipop sticks for inspiration. By going for simplicity they avoided what Crowley calls the "robot traps" of getting into standard humanoid creations, or even the automaton robots of modern assembly lines. "We just needed a workhorse robot that was all about function," the production designer explains. "We started drawing these stick things. I brought in a model maker, and we started playing with magnets and looking at how we could take these divisions that could unravel into something that was geometrically a division of itself. It was then that TARS started to appear."

"A robot can be all sorts of incredible things; it doesn't need to be shaped like a human being."

Paul Franklin compares the robots to the "simple, clean shapes" of sixties-era abstract sculpture. "A robot can be all sorts of incredible things; it doesn't need to be shaped like a human being," he says. "At the same time, these things are intelligent and have conversations with the other characters. They have distinct personalities: TARS is the main robot and has a sense of humor; CASE is reserved and taciturn. Chris wanted to have an actor driving the robots, and he found this fantastic performer, Bill Irwin, who puppeteers and provides the vocal performance. Again, it was [a practical approach] that gave the other cast members something to act against."

Bill Irwin was working as an off-Broadway "clown and actor," as he calls it, when his agent informed him that Christopher Nolan wanted to talk to him. On the phone call, Nolan, who was in Los Angeles, never once used the word *robot*: "Chris referred to these characters as 'machines' and 'articulated planks.' I was getting a picture of what he had in mind and said to him, 'This reminds me of when you work with animals in a zoo or circus and they get old and sluggish, but suddenly there is a need and they [move very quickly], surprising the humans who think they're in charge. There was a long silence at the other end, and then he said, 'Yeah, yeah.' I thought, 'Maybe that wasn't the stupidest thing I could have said.'"





OPPOSITE Unlike the humanoid robots of most movies, *Interstellar* robots TARS and CASE were flat and unadorned metallic forms that moved by "unfolding," Scott R. Fisher explains. **ABOVE** To bring the robots to life required the skills of performer Bill Irwin and the combined efforts of special effects, visual effects, and the stunt department. **ABOVE RIGHT** Conceptual studies show a number of potential finishes for the robots.

Upon getting the role, Irwin began to flesh out the characters. He imagined CASE as having superior circuitry to TARS but being a less experienced machine and pilot, while TARS had a sense of humor and a military feel—"ex-Marine, possibly," he muses. "It was my job, and the job of the incredible stunt players, to have a strategy for bringing these machines to life," he continues. "I [ended up] projecting the fact that these articulated machines, by some sort of fluke of circuitry and the beginnings of artificial intelligence, were as emotional as any of the other characters. For TARS and CASE I kept looking for what their function was and how they saw themselves in the lives of the human characters."

During pre-production, Irwin visited the special effects shop, where he saw TARS and CASE being created, the final models incorporating a compressed air device that moved the robots' limbs. Irwin likens the final button-pushing rig to a video game. "I've always been terrible at video games, but suddenly I had to become a gamer," he says. "Of course, there was also the muscular effort of moving two-hundred pounds, but then we found different joint arrangements to make the machines walk. Paul Franklin and the geniuses at the visual effects department would provide a lot of the articulation, but the foundation was up to us."

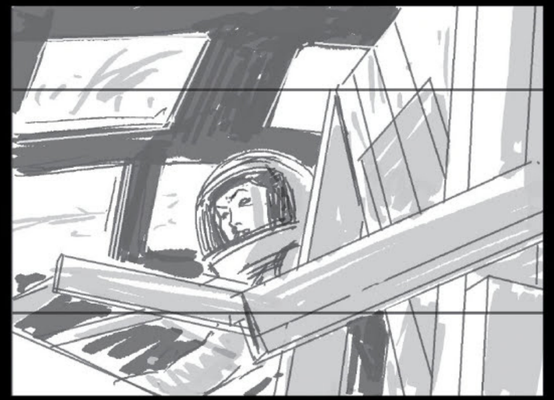
> "For TARS and CASE I kept looking for what their function was and how they saw themselves in the lives of the human characters."

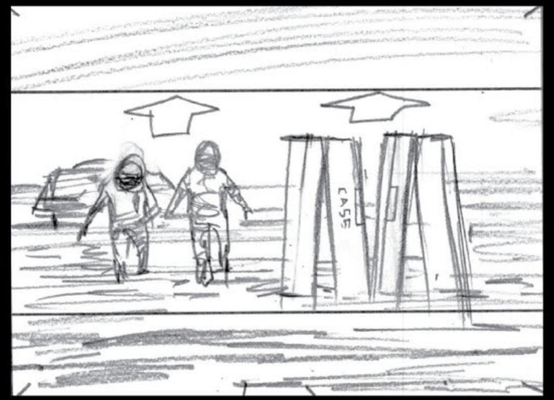
Bringing TARS and CASE to life required a "whole array of strategies," Irwin notes. The robots were even flown on wires for some shots while Irwin delivered his lines off-camera. "This has been a gig where just about every aspect of the acting craft had to come into play," he says. "There was even running with crampons on a glacier!"

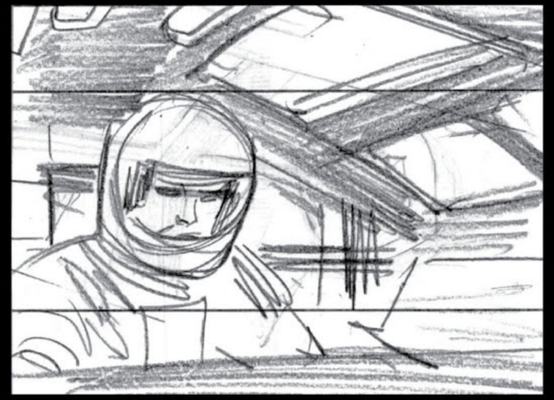
In addition to the main "walking robots," as Fisher calls them, special effects built different robots for different filming situations, including close-up robotic arms that could fold out and perform various functions, sometimes requiring two or three operators (the director often pitched in to operate the close-up arm's specialty functions). For some scenes, Double Negative provided a CG solution. "We worked out how to animate these robots to do the extraordinary things the real rig couldn't do, yet have it within the same physical language," Franklin explains. "It couldn't suddenly turn into a superhero robot and fly around. We tried to make it seem mechanically plausible at all times."

LEFT When a Ranger is in flight, TARS can interface with the ship directly, making him an indispensible part of the flight crew.

TARS







OPPOSITE TOP LEFT TARS and CASE bear their names on their outer shell in both regular type and Braille. **OPPOSITE TOP RIGHT** TARS reports to the flight deck. **OPPOSITE BOTTOM** Concept art shows a number of color schemes considered for the robots. **ABOVE** These storyboard panels show that the robots of *Interstellar* were designed to function in any number of environments, including the treacherous climes of the ice and water planets.

ZERO-G

The weightless zero-gravity effect included practical touches ranging from books and clipboards suspended in the air on thin wires to actors and stunt doubles floating around the interiors of the spacecraft. The floating effects for *Inception* demanded versatility in their methodology and provided practical experience for *Interstellar*, Nolan explains: "We also knew, from a creative point of view, the relative value of zero-gravity effects, such as where they impress and where it's not really that big a deal. So, we were able to shoot a lot less of those things than if this had been our first time trying to portray zero gravity. You can get very bogged down and obsessed about it for its own sake, but it's only interesting if it's part of the story. We were able to use the knowledge we gained on *Inception* for how to build the sets, how to put the wire rigs in, when to use which method. That experience saved us a lot of time and trouble."

"From the beginning, we were made aware we had to use zero-g on every set, so we had to be prepared to do it in the *Endurance*, the lander, and the Ranger," stunt coordinator George Cottle notes. "The problem with the *Endurance* is it was so enclosed we had to be very cheeky and resourceful as to how to float the performers in there. But I love the challenge when Chris comes to us and says, 'Okay, I want to do *this*,' and your first reaction is, 'I don't know *how*.' You step away for an hour or a day, make a plan, and come back and achieve it."

"Like a seesaw, an operator could lift the rig on their end, moving the performer up and down or side to side."

The solution for flying the tight quarters in the *Endurance* was the same elegant, wireless approach used on *Inception*. The "parallelogram," as it was called, was likened to a miniature camera crane or playground seesaw. The special effects setup had a counterweight at one end and the performer at the opposite end. Like a seesaw, an operator could lift the rig on their end, moving the performer up and down or side to side.

"We put [the performers] in what's called a hip swivel harness," Cottle explains. "There was a little swivel we connected to a wishbone-looking contraption off the front of the parallelogram. Once they were connected, this rig would essentially 'float' them through the tighter, more confined spaces. If

LEFT Six weeks of pre-production wirework prepared the actors and their stunt doubles for the challenge of replicating zero-gravity conditions.

we were doing close-ups or an over-the-shoulder of their hands on switches or buttons, we could hook the rig to their waist and float them out and into chairs. Chris Nolan was always on the other end, manipulating it. He'd say, 'Okay, I'm going to move you here,' or, 'Flip that switch, now I'm traveling you over.' He absolutely loved it!"

"I'd learned on *Inception* that it's really a puppeteering job," Nolan says of operating the parallelogram. "The effects guys are great at setting everything up and getting it ready to go. But I found on both movies that the best way to get what I wanted in terms of the feeling of floating was to operate that [rig] myself with Scott helping me do it; with him checking the safety aspects and figuring the mechanics of the weight of it."

"You're in a full harness and it's four strings, and you're fully suspended—you lean up, you come up; you put your head down, you go upside down," says McConaughey of the experience. "[The wire rig] is actually a little more comfortable than the parallelogram, which is sort of a pitchfork with a plate on it and you're strapped into a harness on your hips."

The zero-g work on the Ranger interior featured a vertical set built by the art department on Sony Stage 27. The Ranger interior could be positioned vertically and horizontally, allowing for wire flying from all camera angles.

ABOVE Zero-g filming continues as a performer "floats" through one of the modules aboard the *Endurance*.
OPPOSITE BOTTOM LEFT The director takes charge of the parallelogram, a small crane arm rig that complemented the zero-g wirework.
OPPOSITE BOTTOM RIGHT Christopher Nolan sits on top of an 80-percent-scale Ranger model as Hoyte Van Hoytema looks on.
TOP RIGHT A vertical version of the *Endurance* set allowed filmmakers to capture scenes of actors dangling in space that could be flipped horizontally in post-production to create the illusion of zero-g floating.

Mixing up techniques was part of the movie magic Nolan practiced on *Inception*. "Chris brought it to my attention," Cottle reveals, "that if we perform a stunt or a wire trick too long, people will go, 'Oh, *that's* how they do it!' That really stuck in my mind. You have to keep mixing it up, whether changing pick points [where wires attach to a harness], or rotating whatever it is you're floating them around in. It always keeps them guessing, you know?"

"The Ranger interior could be positioned vertically and horizontally, allowing for wire flying from all camera angles."

OFF TO ICELAND

Before the *Endurance* stage work began, the cast and crew faced a grueling shoot in Iceland at a number of remote locations. The preparation for this crucial phase of the filming was one of the first production challenges, requiring the building of 80-percent-scale Ranger and lander spacecraft for exterior work. It was "an enormous logistical burden" executive producer Jake Myers explains: "We had to start building the ships before we did anything. We were on a much tighter time line than even the corn grow. The Ranger and lander were built in Burbank; carved out of foam, [they] had solid fiberglass exteriors and weighed around 30,000 pounds. We had to chop them up, fit them on a cargo plane, and fly them to Iceland. We hired a construction crew, led mostly by people from California, to reconstruct these ships on the water location that was fifteen kilometers up that [bad road that had to be rebuilt]. When we were finished shooting there, we had to move them from the water to the glacier." Myers also had to arrange for two helicopters to carry out aerial photography in Iceland, along with the construction of a small airfield atop the glacier for shuttling crew and equipment when they filmed at the peak.

Emma Thomas observes that Iceland was "an extreme version" of the kind of location shoots regularly undertaken in Los Angeles. "Film crews are amazingly adaptable," she says. "You have this enormous group of people who often haven't worked together before, and they're supposed to work as a team in places that half of them haven't been before. It's really an incredible machine, a film crew."

That resiliency would be tested—the production shot in Iceland in early September during the onset of winter. "Iceland is generally a tough place to work, at least the places we chose," says Scott R. Fisher. "The water planet involved standing in two-and-a-half feet of water all day, and at the glacier everything was uphill and downhill and slippery. It was very physical, very demanding."

While the main unit was still working in Canada, Cottle sent an advance team to the glacier to rehearse the wirework and shoot reference video. The water planet was fixed at "120 percent gravity," Fisher explains, meaning a heavier gravitational pull, which was created through the actor's performances. But the ice planet was 80 percent normal Earth gravity, which, as a story point, required the forearm thrusters. Cottle's stunt department worked out and rehearsed a formula for rates of deceleration as the astronauts slowed and safely landed in free fall, or accelerated when they needed to ascend to a high point on the ice.

> "It was about doing the research and putting it into practice."

For scenes where actors needed to be pulled through the waves on the water planet, Cottle's pre-production prep included looking into old military vehicles that could drive through water and accommodate wire rigging. The locations manager in Iceland found a vehicle Cottle likens to an Army Humvee that was low to the ground and had massive wheels and a big flatbed. "It looked like it had been to a war and back, but we basically rigged our whole stunt world on the back of this truck," Cottle says. "We had pick points on it, the truss and ram. We were totally mobile. We could click the rig on, drive into position, and were good to go."

The stunt department was lucky to have team members who were former Alpine climbers. "They were all very aware of their surroundings and how hostile the environment was going to be," Cottle adds. "We went with ice axes, and variations of how we were going to secure and test the rigs, making sure the hydraulic ratchet was insulated, because in cold temperatures it would react differently to all the settings we had back in Los Angeles. It was about doing the research and putting it into practice. If you're prepared, then it's just putting up with the cold."

RIGHT The practical lander model in Iceland. The production's first major challenge was building the 80-percent-scale lander and Ranger in Burbank, before disassembling them for a cargo plane flight for Iceland, then reassembling the sections at the location.

CHAPTER 7: OTHER WORLDS

ARRIVING IN ICELAND, the filmmakers were ready to put into action all their meticulous preparations. "We tried to imagine what it would be like to come to a planet, get through the stratosphere, and put your foot on the soil—how does that feel, what is that communicating to you?" says Hoytema. "We wanted it to be very tactile and real, to feel those worlds rather than just marvel about them and create some sort of artificial magic."

The filming emphasized Nolan's concept of each world being an elemental extreme. "When we shot in Iceland, Hoyte and I joked that we weren't shooting any of the spectacular landscapes," Nolan recalls. "We were shooting the icy vastness of the glacier, rather than trying to frame in the mountains. We were trying to reduce each planet to its absolute elemental quality and not feel too much variety."

Despite the harsh conditions, the cast and crew were ready to meet the challenge. There was also the director's example, Goldberg adds: "Chris leads from the front. He never leaves the set, ever, *ever*! He never goes to his trailer. There's no 'video village.' There are no chairs. It's him and he's next to his DP, he's with the actors, and they're just going. It's hard to back down if your fearless leader is fearlessly leading."

"My filmmaking has only ever worked from being at the camera, being right there with the actors," Nolan explains. "I've never been able to sit apart in the video village, as they call it [watching monitors display the camera work]. That is not inspiring—you're looking at a two-dimensional image, so everything becomes two-dimensional. I feel that my job is to be on the set, with the crew. That's my approach, no matter the conditions. And if there is discomfort to be experienced, I should certainly be experiencing it along with everybody else. On a practical level, I then have an understanding of how long we should be doing something. I also think if you're in there doing it, that's encouraging to people as well, particularly when you're in difficult conditions. I also think it's tremendous fun to get in and do things you normally wouldn't do, challenging yourself in different ways."

OPPOSITE Crew and crane prepare the Ranger for filming in Iceland. **FOLLOWING PAGES** Two members of the *Endurance* crew with a Ranger craft on the water planet.

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TOP LEFT, BOTTOM LEFT, AND OPPOSITE The Ranger is put into position at the Iceland location. The logistics of getting practical spacecraft to Iceland was daunting—it would have been easier to computer generate them—but the production fed off the visceral impact of interacting with real objects and places. "We wanted the audience to feel this could exist," Nathan Crowley says.
ABOVE Wes Bentley braves the icy-cold waters on location in Iceland.

the water first.' The water was very difficult. A glacier sounds difficult, and it is, but it's at least solid. But it was exciting being out there in the water, lugging this industrial process of modern filmmaking [into a wilderness environment]."

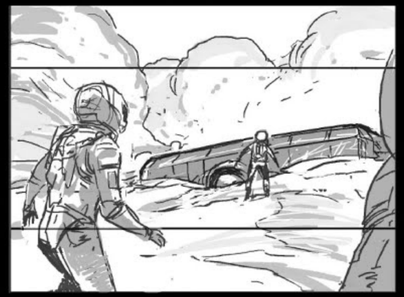
The planet's perils include waves thousands of feet tall, far beyond any earthly reference. A Double Negative crew filmed live-action plates at the location, to which they later added a computer-generated tidal wave. "We were standing out in the middle of this lake for a week, shooting all the scenes," visual effects supervisor Paul Franklin says. "We were in heavy, insulated neoprene wading boots, but it was pretty hard going. And, of course, Icelandic weather is unfriendly, so rain and sleet would come in. But we got amazing images; it has that grounding in reality."

THE ICE PLANET

The ice planet's ecosystem was imagined as melding layers of ice and clouds—icy clouds crystalize and turn into glaciers, glaciers vaporize and turn into clouds. To simulate the descent to the surface through this stormy cloudscape, Franklin and an aerial crew shot plates back in the United States, flying into the teeth of a storm in a Lear jet specially equipped with a nose-mounted IMAX camera. The main unit was filming on the soundstage sets at Sony when Franklin got word of a massive storm system over Louisiana.

"The glacier was a very weird and unworldly environment."

"We had to scramble the aerial unit at twelve hours' notice to meet the storm front as it came across the United States," Franklin recalls. "We were hurling the Lear jet around in the sky, banking around clouds, trying to follow the flight path we knew our spacecraft would fly on. It was a bit worrying, but the pilot assured me it would be okay



RIGHT Concept art shows the *Endurance* crew warily approaching an abandoned ship on the ice planet. **ABOVE** A storyboard depicts the same scene.

Cooper (*above*) and Brand (*above right*) explore the desolate ice planet. **OPPOSITE** Christopher Nolan (*top*) finds himself caught in very real storm as Cooper (*bottom*) endures the worst that the ice planet has to offer.

if we didn't get too close. We were skimming the clouds and it made imagery you'd never be able to create on the computer, a fantastic basis to work from."

The "Batman glacier" itself was an awe-inspiring location, as strange and alien as if the production had truly landed on another planet. "The glacier was a very weird and unworldly environment," Franklin attests. "It's surrounded by stark and foreboding volcanic mountains covered in broken lava fields that, in turn, are covered by a thick layer of green moss. It was a very strange atmosphere."

Shooting there was "very, very challenging," costume designer Mary Zophres recalls. "We had crampons and actors in spacesuits on top of the glacier, where you could only get to by helicopter. Things were breaking and falling off—you won't see any of it in the movie, but it was stressful. We lost a couple of helmets that ended up in pieces on the glacier. We were getting the kinks out. If we had started on stage it might have been easier, but I'm glad we started in Iceland. We got the hardest part over with first."

THE STORM

Filming on the glacier was unexpectedly interrupted by a ferocious windstorm. On an early *Interstellar* Iceland scout, Nolan had asked a local about weather conditions in September, when they would be filming, and the man replied that the previous year a windstorm blew the asphalt off the streets. "He said it nonchalantly, and we all laughed," executive producer Jordan Goldberg recalls.

But another September storm blew in, hitting the glacier with 100-mile-per-hour winds. "This was a storm that *literally* blew the asphalt off the streets!" Goldberg describes. "I'm a pretty big guy, and I'd never been in wind where you're actually blown backward. The combination of wind and being on ice is not good. But you don't go into those situations without a system already organized, and Jake Myers and Daniel Stillman, the UPM [unit production manager], worked with the Icelandic guys. We all had a number; we were always

CHAPTER 8: INTERSTELLAR SCIENCE

KIP THORNE WAS DRIVING ON California Interstate 5, somewhere west of Fresno, when he suddenly realized how a super advanced civilization might keep a wormhole open. At that time it was believed that wormholes opened and closed so quickly nothing could enter and survive, but Thorne began to wonder if a super advanced civilization could theoretically keep a wormhole open by threading it with "exotic material."

As a result of his groundbreaking work on wormholes, Kip Thorne became the scientific spirit behind Michael Caine's character—it is Thorne's equations that fill some sixteen blackboards in Professor Brand's office. "Chris wanted to put in the idea of the professor struggling to understand gravity, and we discussed the details of that at considerable length, and then he had me fill the blackboards with the equations," Thorne notes. "The professor's goal is to control gravitational anomalies, things beyond the frontier of knowledge that are controlled by the laws of quantum gravity. This includes a full understanding of the birth of the universe, and, very likely, whether you can create wormholes—all of this is alluded to in the movie under the rubric of the 'quantum data' that the professor needs."

Not only did Nolan and Thomas embrace the idea of making theoretical phenomena seemingly real and observable, but Thorne worked closely with Paul Franklin and his Double Negative colleagues, a brilliant group that collectively holds PhDs in math, physics, and computer engineering. The process began with Thorne writing equations for the black hole; for instance, adapting calculations made by other scientists in the past. "We have a huge amount of evidence that the universe is truly governed by the laws of physics, which explain what we see and predict things before we see them," Thorne explains. "These laws of physics are couched in the language of mathematics. So, I take a question, such as whether it is possible to sit on a planet for a few hours and have years elapse on Earth, and that becomes a mathematical question. I work with the laws of physics and mathematical language."

OPPOSITE Visual effects house Double Negative used Kip Thorne's calculations to create incredible deep space visuals, such as the black hole Gargantua.

Thorne first tested his equations for the wormhole and black hole by building low-resolution imagery in Mathematica, computational software popular with physicists and engineers. He then sent the results to Oliver James at Double Negative in London. Once Thorne and James worked out any problems and were happy with the results, that data was then sent to D-Neg's Eugénie von Tunzelmann. "She led the team that basically took the overall code written by Oliver James and converted that into an artistic and compelling shape, such as the placement of the [virtual] camera, adjusting what nebulae and stars go around the black hole," Thorne says. "In the end, Chris Nolan and Paul Franklin did the big-picture stuff; they gave instructions on how to torque everything to bring it into the form they wanted."

Thorne's equations were ultimately converted into proprietary software that Double Negative called "Worm Renderer," and that was used for both the wormhole and black hole. "The software could calculate, say, how light rays bend in space around the black hole," Franklin explains. "The first test image looked, frankly, unspectacular, but they fiddled with the parameters, increased some variables and reduced others, and suddenly produced extraordinary imagery I never expected to get. The scientific reality really was stranger than fiction, stranger than anything I had encountered.

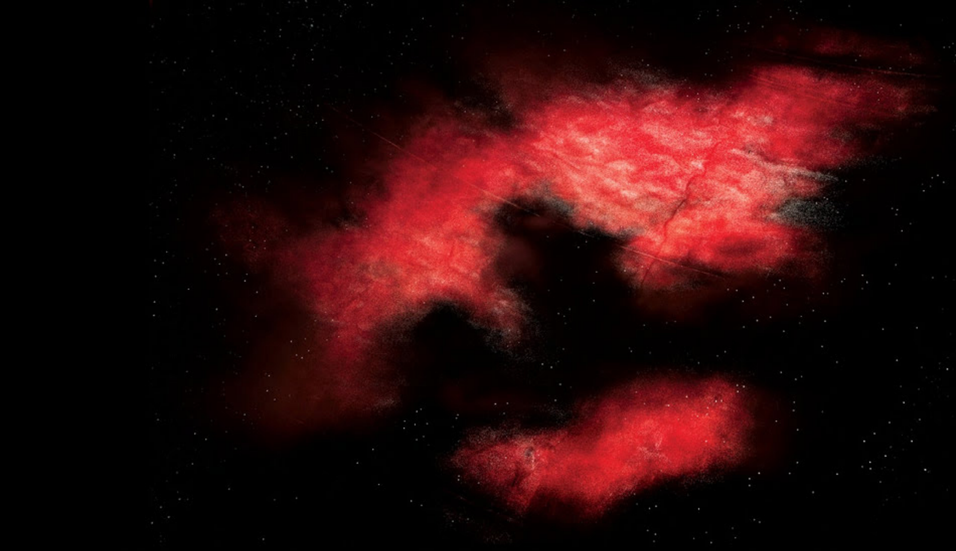
"Science fiction can tackle the biggest ideas in the universe, but most science fiction films don't attempt that at all," Franklin continues. "You can think of a couple key examples, the best being *2001: A Space Odyssey*, and that was made nearly fifty years ago. *Interstellar* is tackling ideas on that scale. It's about time and space and the biggest astronomical structures. It was an enormous canvas we were working with. We have, perhaps, taken the visualization of these things further than anybody so far, and I think we got something quite unique. What brought that home to me was at one point we were visualizing what you might see as you traveled into a black hole, and we started getting some strange results from our software. We contacted Kip and asked, 'Should this be happening?' Kip replied, 'Well, I'm not really sure. No one has ever visualized this before!'"

Thorne explains that writing the computer code for the exterior of the black hole was fairly straightforward. "We'd say, 'the black hole has no hair,' which meant that as soon as you knew its mass and how fast it's spinning, you know everything about it, its full geometry of space and time. You didn't have that many choices about the black hole, other than the nature of the nebulae and gases around it. The wormhole had more possibilities, so I built a mathematical model for it that could be adjusted as far as its size, length, and shape near its openings at the two ends. Oliver James and Eugénie von Tunzelmann and their team then produced visualizations for the various choices, and Chris and Paul made the decisions as to what they wanted for the movie."

The final choice was to give the wormhole a moderately sharp edge when viewed from the outside, with the stars appearing to dip around it in one direction, while the more distant stars dipped in the opposite direction. "This is a result of what we call 'gravitational lensing,' the bending of light rays near the wormhole," Thorne says. "If they had chosen to make the wormhole shape less sharp, the transition from inside the wormhole to the external universe would have shown a much larger region where images are distorted. But [their final choice] was still accurate to the equations. I built equations that enabled them to make choices, and it was just a matter of them making a choice of what kind of wormhole they wanted."

Basing cosmic imagery on real science was vastly superior to anything they might have simply conceptualized on their own, Nolan explains: "I believe that what Kip has been able to do on this film is use this Hollywood machine, as it were, to visualize things that he's known the mathematics of for quite a long time but hasn't had the graphics capability to fully visualize. [Thorne and D-Neg] had a great partnership in exploring these things. My only concern was you can get bogged down in the science, and you might not get something that would communicate as effectively the idea you're trying to portray. But what we rapidly found was the real science gave you different imagery you never could have predicted or imagined. That speaks to my original notion of wanting to photograph things for real wherever possible. I believe that nature has a degree of complexity and serendipity far beyond what

OPPOSITE Professor Brand (Michael Caine) and Cooper discuss the interstellar mission in the NASA scientist's office. Consultant Kip Thorne provided the equations spread across the chalkboards in the background.
ABOVE Caine poses with the real scientist behind Professor Brand, Kip Thorne.



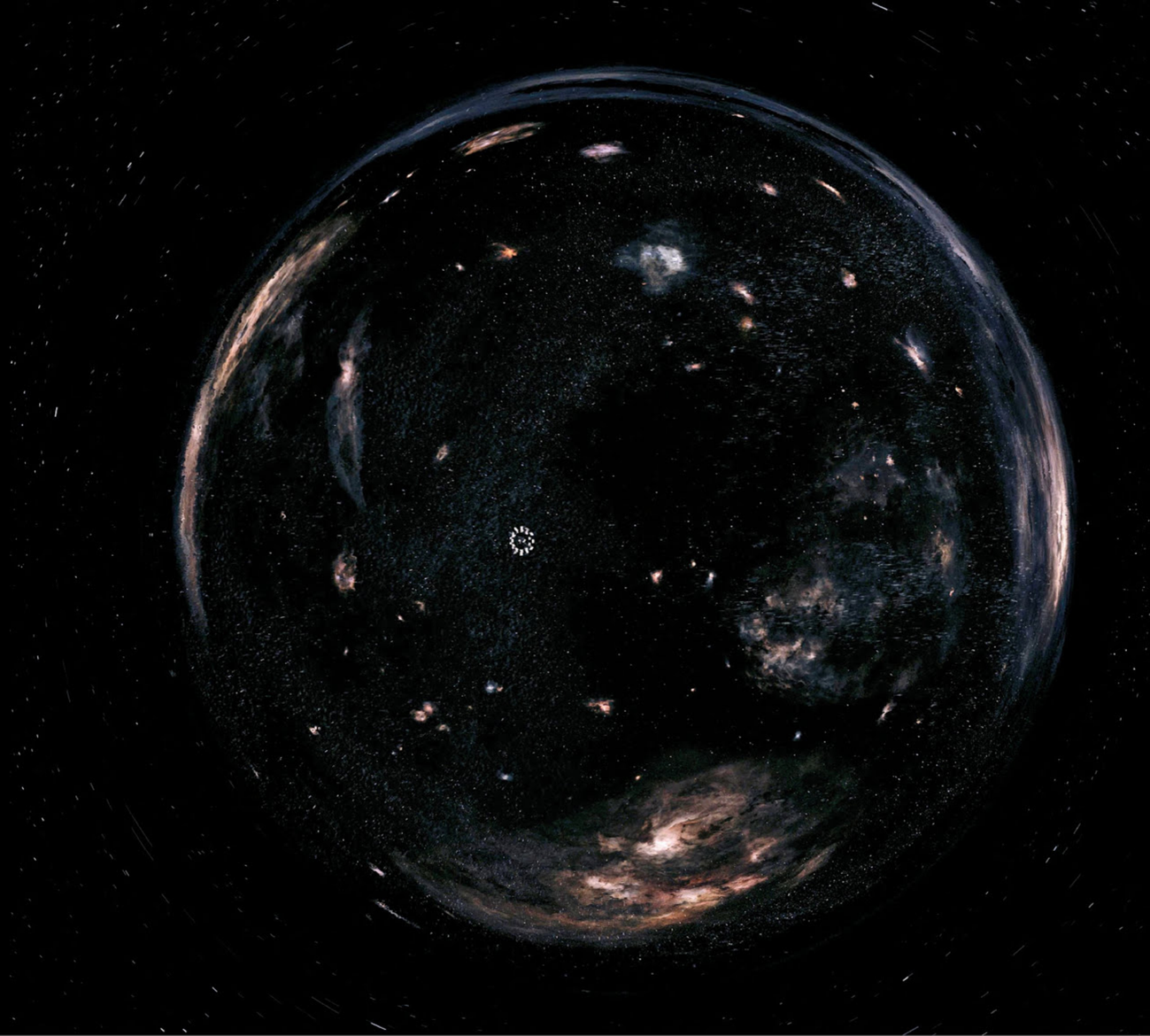
you can simulate. And these computer-generated versions of a wormhole or black hole get into that same realm of complexity, because the real science behind them is so difficult and complicated. A lot went into finalizing the details, but right from the beginning you knew it was going to work and give you something really special."

The production even decided to combine in-camera projections of Double Negative's CG work with filming on the live-action set. Although such CG work would normally be realized in post-production, Double Negative had a year of research and development, and Nolan felt an in-camera approach was possible. "If you know what you have to do in a year's time, and you're not waiting for [background] plates, there's no reason you can't get on with it," Nolan says. "Paul took a leap of faith that we could accelerate the R-and-D process and try to make shots we could project that would hold up. Most of the coverage was [spaceship] interiors, and, particularly in IMAX, the background could be out of focus. I said to Paul, 'If you can come up with something that holds up, we've got an in-camera shot and that would greatly help our shot count and take away a lot of greenscreen, a lot of that trouble.'"

And so, by the time the *Endurance* was ready for filming on Stage 30, the production eschewed greenscreen for image projection techniques, notably traditional front projection, an almost forgotten illusion. Ironically, one of the first features to incorporate front projection, as opposed to more commonly used rear projection, was *2001: A Space Odyssey*—the "Dawn of Man" sequence having been filmed on stage with still photos front-projected on a screen behind actors costumed as apelike pre-humans. "When I first got in the business, when we did movies like *Terminator 2* and *Total Recall*, we used front projection and rear projection all the time," Fisher recalls. "And then it just went away; they went to the greenscreen and bluescreen stuff. It's come full circle."

"I believe that nature has a degree of complexity and serendipity far beyond what you can simulate."

ABOVE LEFT Kip Thorne's equations often led to stunning visuals that surprised even the scientist himself. **OPPOSITE** The *Endurance* heads into the heart of a wormhole.



FRONT PROJECTION

Originally, Nolan considered putting painted backdrops on stage to represent the cosmos. But the idea of closing the doors on the *Endurance*, and having the interstellar voyagers look outside the window and see cosmic phenomena, proved irresistible—the ultimate get-it-in-camera effect. "The projection thing came up as a result of a conversation between myself, Paul, and Hoyte," Nolan explains. "We had screened a print of *The Right Stuff*, a film that embodies a lot of the spirit of what we were trying to get across about the character of Cooper and the drive to get off Earth. What's striking about Philip Kaufman's film is it's really a technical masterpiece. And they did an enormous amount with a very clever use of projection and archival material, like the scene where John Glenn is launched in the capsule, and they're projecting footage that is reflecting off his helmet and the silver parts of his suit. I said to Paul, 'They managed to do that with film projectors. It's so much easier now to do that with digital projectors, why aren't we doing that?'"

The screens were as massive as Stage 30 itself—the biggest was 80 feet high and some 300 feet long, Franklin estimates, although they usually projected onto a 60-foot portion. "The great thing is you actually got this [phenomenon] outside the windows, and it reflected off the surfaces inside the spacecraft," he notes. "We got all sorts of interesting optical effects."

With digital projectors connected to a computer playback system, the Double Negative team in London could send visuals to Franklin through the Internet. "We could also create content on a couple of computer graphics workstations on the stage and bring that into the playback system, creating and tailoring sequences for what Chris wanted to do on the day," Franklin adds.

In addition to projection techniques, the cinematographer's lighting enhanced the illusion of a spacecraft in motion. "We could really sell the movement of the ship," says Hoytema. "If the ship dived, rotated, or turned, it would influence the direction of the light coming in from the outside and you would change your background as well, and let them correlate. You could sit in front of a window and watch the rotation of a projection background and, at the same time, [a lighting effect for] the sun would come in and light an area and disappear again. Playing with front projection came from that philosophy of the more you do in-camera, the more solid the outcome."

"The effect was not dissimilar to a training simulator—your brain simply starts to wrap you into the world you're looking at," says film editor Lee Smith. "No one knew whether it would work or work in every instance. But a huge amount of these shots were untouched [in post-production]; they would be the final product."

"It's nice to look out the window and see space, to have a sense of the infinite and not a greenscreen in your face," Nilo Otero reflects. "You don't have to pretend as much, you can actually live, as much as possible, in that situation. And what the visual effects department did, using very old-school front projection, worked magnificently. It just made the set that much more realistic, and therefore made the film more realistic."

OPPOSITE Christopher Nolan used a wide variety of classic techniques to get the realistic look he wanted for *Interstellar*, including this dangling planet prop. "Rather than shoot [the *Endurance*] against greenscreen and later add the wormhole, black hole, and other things, Chris and I thought it would be interesting to incorporate that imagery into the set," Paul Franklin explains. **ABOVE** Eschewing greenscreen, a deep-space scene is filmed against a specially created backdrop.

MINIATURE MAGIC

Along with front projection, another classic but underutilized filmmaking technique was adopted by the *Interstellar* crew. Miniatures produced by outside vendor New Deal Studios augmented the full-scale soundstage spacecraft to remarkable effect. "If he had a choice, Christopher Nolan would be shooting in space with real spaceships, but the next best thing is to shoot miniatures," says veteran effects artist Ian Hunter, New Deal's supervisor on *Interstellar*. "It's an old technique, but still a very good technique."

The word "miniatures" was something of a misnomer—the models built and shot at New Deal ranged from a one-fifteenth scale version of the *Endurance* that was some 25 feet across, to a one-fifth scale *Endurance* section that included a 12-foot-long Ranger and three modules that were 45 feet across. Even the 80-percent-scale Ranger and lander used on the Iceland shoot were utilized: "We decided to shoot them on motion bases and fly them around as if they were very large miniatures," says visual effects supervisor Paul Franklin.

The model work on *Interstellar*, which totaled around 150 shots, marked a return to a technique Nolan had successfully employed on his previous films, including *Batman Begins* and *The Dark Knight Rises*. "A lot of filmmakers have strayed away from models, because they think it will be too expensive and time-consuming," says Franklin, who supervised the New Deal shoot at the studio's facility north of Los Angeles. "But once we committed to building the models and getting them up on a stage, we just charged through the work."

One impetus to use model work was the inherent realism that a practical approach would bring, particularly for scenes featuring complex elements such as large explosions. "Straightaway [a pyrotechnic event] suggests miniatures because you can get unexpected results," Franklin notes. "Simulating all the bits and pieces in CG can look contrived. We wanted to maintain that sense of realism."

New Deal's one-fifteenth scale *Endurance* model included the attached lander and Ranger, each two to three feet long. Although they were detailed, there were concerns the smaller Ranger and lander wouldn't be suitable for the close-ups the filmmakers needed to capture. "They held up pretty well, and we used them as much as we could," Franklin notes. "But we wanted to have shots where the camera is hard-mounted to the side of the Ranger as it's reversing into the airlock on the *Endurance*."

Rather than using a CG solution or building another scale Ranger model, the visual effects team decided to utilize the 50-foot-long spacecraft made for the shoot in Iceland. Working with Scott R. Fisher's team, the huge model was mounted on a hydraulic motion base, and the cinematographer lit and shot it with an IMAX camera. "There was an interesting character to the Ranger, because it had been battered by Icelandic weather, with howling gales and rain and sun, the kind of random events you couldn't have gotten digitally," Franklin explains.

The lander was also hoisted onto hydraulics so that both ships could be manipulated on a six-axis motion base for everything from the coupling of docking scenes to the roiling action of buffeting waves on the water planet. "Any form of movement was available," Fisher explains. "We did the Ranger and the lander one at a time, rotating them through, to get all the elements we needed. It was difficult to program because there are six different cylinders that have to move in harmony. But you can move it in real time with what we call a Waldo. Most of the time, Chris controlled it himself and he really enjoyed doing that. He was the one who knew what the ships should be doing. We could then record those moves and play them back if multiple takes were needed."

For a spectacular scene where the Ranger plunges into a black hole and is blanketed by strange colored lights and misty particles, Franklin's team first-contemplated CG animation but later decided to keep it old-school. The one-fifth scale, 12-foot-long Ranger was mounted straight up on its tail, and a 100-foot crane dumped hundreds of pounds of household table salt on the model as it was filmed at high speed. Once again, the practical approach produced the unexpected. "The salt formed these extraordinary patterns as it spiraled down and interacted with the model, bouncing off the surfaces and skittering around, and catching the light with little bits of sparkle," Franklin says. "We also poured thousands of pyrotechnic sparks that gave it a very tactile feeling."

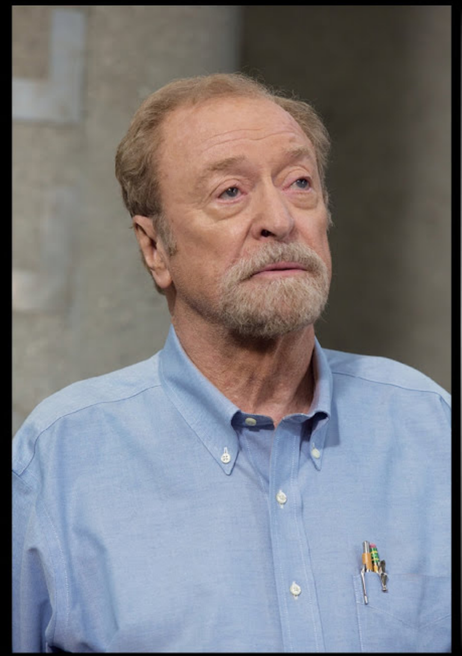
At the end of the miniature shoot, there was still digital post-production work to be carried out on the spacecraft, such as removing model support rods and mounting equipment, but the in-camera work helped keep this to a minimum. "The bottom line is the guys over at New Deal Studios, who have been our longtime collaborators back to *Batman Begins*, did an absolutely spectacular job," Franklin concludes. "I was blown away by the quality of what they managed to achieve and the flexibility it gave us in post-production. Rather than wait for the digital sausage factory to churn things out, Chris and Lee could be assembling the film. The miniatures work definitely led the way."

OPPOSITE The one-fifteenth scale *Endurance* model created by New Deal Studios.
BELOW The production filmed large-scale props as if they were miniatures. Here, the 80-percent-scale Ranger is mounted on a gimbal (known as a Waldo) that allowed it to be rocked back and forth at command.

VAGARIES OF TIME

In interstellar travel, impossibly vast distances are inextricably linked to the relative passage of time on Earth. Even in interstellar space, the local time warping of the black hole creates massive time displacements.

The makeup department showed the aging of the characters left behind on Earth, including Professor Brand's transition into old age. For makeup head Luisa Abel, the key was creating a believable illusion, not an obvious makeup job. After long discussions with Nolan, Abel decided to first make the Professor Brand introduced earlier in the film an adult of "nondescript age." She explains: "I researched, with Patti Dehaney, pictures of Michael Caine as a younger man, and we found colors for his hair, eyebrows, and skin tone that suited him. It wasn't a look we forced on him; he really looked as he did twenty years ago. Then, at the end, we did a full aging makeup so he looked much, much older." The illusion of aging included making Caine's skin look pale and sickly, and applying "stretch and stipple" effects. "Stretch and stipple is a process that creates 'character' and lines on someone's face, and allows a makeup artist to age them through painting," Abel says. "It's layering different coloring, using highlight and shade and contouring to change someone's face and make them look older."



LEFT The make-up department deftly morphed Caine's character into old age.
OPPOSITE TOP TO BOTTOM The three ages of Murph: youth, adulthood, and old age, with Ellen Burstyn aged and made up to resemble the previous generations of the character.

Murph's brother Tom ages into a man in his late thirties. "With Casey Affleck's character, we used facial hair because men tend to look older if they have facial hair," says Abel. "One of the things we wanted to show is that they are struggling, working people. Tom's wife and son are not out in the fields working because they're getting sick from the dust, and that was about breaking down their looks so audiences intrinsically know something is wrong."

The biggest makeup challenge was linking the three actresses playing Murph across youth, adulthood, and old age. "Part of that process was looking at the three women to find things that would allow me to create Murph," Abel notes. "Either through makeup or, as in the last transition, through prosthetics and stretch and stipple, we were able to use a portion of each actor to create one character. Everything from eyebrow shape to nose shape were incorporated. With younger people, their nose shape and features change as they get older, so we felt that other than matching their skin tone and eyebrow color, it was believable that Jessica Chastain was the aged version of the younger Murph."

The big transition, from adulthood to the elder Murph played by Ellen Burstyn, required a complex melding of prosthetics and aging makeup. "We used life casts from Jessica Chastain for the shape of her chin and nose, and then created a prosthetic nose and chin that looked similar to Jessica's Murph but also suited Ellen Burstyn," Abel explains. "By the final stage, we had a well-known actress look like Murph, as opposed to looking like herself."

The depiction of the relativity of time was one of the concepts that drew Nolan to the project in the first place and was at the heart of the original idea.

"There's the connection between human beings and what that may, or may not, mean," Nolan muses. "I like the idea that we are imprisoned in the temporal, three-dimensional spatial world and don't necessarily understand what all the facets of human nature mean. Time feels like a particular experience to us, but if we could view ourselves from a higher dimension, we might well see that these connections actually mean something different. That's really the point of the Tesseract."

CHAPTER 9: THE TESSERACT EFFECT

IN THE MID-NINETEENTH CENTURY, the Boulevard du Temple in Paris was a lively, bawdy theater district. But a photographic image shot there by Louis-Jacques-Mandé Daguerre (of "daguerreotype" fame) in the spring of 1838 captured none of this celebrated street life, only the streets themselves and the lone shadow of a man in a frock coat who appears to be having his boots shined by a blurry bootblack. Considered one of the first, if not the first, photograph of a human (or humans), the daguerreotype process took several minutes to reverse-expose the image on a glass plate, so long that anything in motion—horse-drawn carriages, shopkeepers, bustling crowds—simply disappeared.[12]

Double Negative researched the capacity of photography to distort and transform perceived reality for the Tesseract, a fantastical space that Cooper explores. "We looked at the early Victorian photographs where film stocks weren't fast enough to record something fast moving, so you got blurred ghost images of people walking," Franklin notes. "We were interested in that sort of idea. The key difference is we were trying to figure out how to record that in three-dimensional time space, so you could look in a room and see a record of everywhere objects and people had moved over the room's existence."

Kip Thorne, although not involved in creating the Tesseract, salutes Christopher Nolan for coming up with a dramatic take on the concept. "You can begin with a square and if you move it perpendicular to itself in the third dimension, you get a cube; if you move a cube perpendicular to itself in a fourth space dimension, you get a Tesseract," Thorne explains. "The Tesseract in the movie is a much more complicated, and much more interesting and fascinating, modification of the concept, and is Christopher Nolan's invention. Just as a cube can live in our three space dimensions, the Tesseract is an object that can live in higher dimensions. For a century, physicists have regarded time as the fourth dimension, and in *Interstellar* there is one more space dimension that leads out of our universe into the so-called 'bulk,' and that's the fifth dimension. Chris's variant of the Tesseract turns space dimensions into time dimensions in an intriguing way."

OPPOSITE Strange, unexplained patterns form on Murph's bedroom floor.

A nexus of the Tesseract, what Franklin calls a "membrane," manifests within a bookcase in a bedroom at Cooper's farmhouse, where the forward-flowing time experienced on Earth intersects with the fourth-dimensional fabric where time is not only infinite but a physical and navigable dimension.

"Chris's variant of the Tesseract turns space dimensions into time dimensions in an intriguing way."

SLIT-SCAN

As a way of cracking the Tesseract, Franklin's team was drawn to slit-scan photography. "Slit-scan" was an innovative use of streak photography adapted by visual effects wizard Douglas Trumbull on *2001: A Space Odyssey* and used for the striking sequence featuring the Stargate corridor that takes a lone astronaut to the ends of the universe.[13] Franklin's crew studied the slit-scan process used to photograph racehorses crossing a finish line. "Rather than record everything happening in space at one moment in time, this process records a single vertical slit over a period of time," Franklin explains. "Only moving objects, in this case horses, moving past the slit are recorded, while the background—anything not moving—becomes a streak. We were very intrigued by this idea, because it was a way of manipulating time within an image. Our challenge was how do we extend that into a sequence that still has to tell a story? It can't just be a still image."

Double Negative ultimately developed their own software that emulated a three-dimensional version of the slit-scan technique. "A key part of our Tesseract set was working out a shelf of books as viewed across space and time, and our research into slit-scan and how to record a period of time into a single image eventually crystalized the way we treated that," visual effects supervisor Paul Franklin explains. "The bookcase itself becomes this extraordinary object that is streaked out into huge stripes, columns that stretch off into the far distance. But what we're actually looking at is not the bookcase stretched out physically but a record of its existence back through the past and into the future."

The director was adamant that the Tesseract be grounded as a physical set, despite its fantastical, time-bending premise. "I felt very strongly that the sections of the film that are the most fanciful are the ones where if you simply shoot things greenscreen, and give yourself over to the computer world of animation, you're going to lose the audience's trust in the reality of things; it's going to become too surreal," Nolan explains. "So it was very important to build the Tesseract set. That was why I brought in Nathan very early on, because even for the more otherworldly elements

OPPOSITE Father and daughter investigate a strange phenomenon in Murph's room. **ABOVE TOP AND BOTTOM** On wires, Matthew McConaughey is flown through the weightless space of the Tesseract set.

of the script that would traditionally fall under the purview of visual effects, it was very important to me that the art department be involved in the design and be responsible for building as much of it as possible."

THE TESSERACT SET

Nathan Crowley calls the Tesseract his most collaborative design ever, "a massive thought process" between himself, Franklin, and Nolan. The Tesseract marked principal photography's conclusion and final creative challenge.

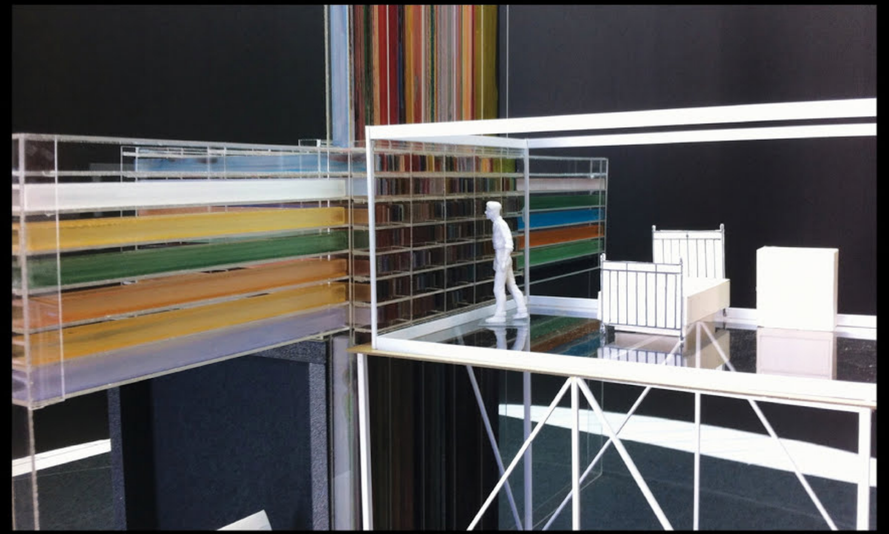
"The Tesseract was the first thing we started talking about and it was the last thing we finished," Nolan notes. "It took a very long time to figure out. I was looking for a way to portray a multidimensional reality in three-dimensions. We were trying to portray time as a physical dimension or as Kip would say, more correctly, a spatial dimension."

Working together, Crowley's art department and Franklin's visual effects team had to figure out where the physical set left off and digital effects began. The physical set had to convey that sense of infinity and allow for such practical filming realities as wirework to simulate the weightlessness of an explorer floating through. "The ultimate challenge was to turn it into a set, put an actor in it, shoot, and work out how to make it look extraordinary through visual effects," Franklin says. "We talked about building a physical copy of the room containing the bookcase, and making that the heart of this space [created through] this three-dimensional slit-scan process. There was a lot of working out how we could make this a comprehensible space for the viewer and, more important, for our film crew to navigate and put lights in and hang actors on wires and fit in cameras. That took quite a long time."

"We ended up figuring it out by the time of the shoot," Crowley adds. "It was a very last-minute set. I came at it from an architectural side, Paul Franklin sort of from a mathematical side, and Chris from a story theory side. It took all three of us to wrap [our minds around this idea] and come up with our own set of rules."

The Tesseract set built on Sony Stage 27 was designed around the notion of an x-y-z axis, with three replicas of the bedroom suspended and joined at those three junctures. Each physical object had an "extrusion," as it was called, of itself, where a plane of an object, such as a chair, looked stretched. The farmhouse bedroom set in Canada was measured at 20 feet long, 15 feet wide, and 9 feet tall. For the Tesseract soundstage set, the location interior was replicated three times, each separate bedroom object linked to the other to form a physical set 60 feet long, 45 feet wide, and some 27 feet tall.

"We decided early on that the Tesseract is in the black hole, so there's no floor or ceiling," Crowley explains. "So we had to have these rooms floating on the soundstage that are connected to one another by a flow of furniture and objects. We supported a lot of the set on a giant steel structure that we blacked out so you wouldn't see it. We had a lot of cabling, a lot of the objects supported by the steel. The Tesseract is geometric, repeating—it's like looking at slices of time in this room. It looked like an art installation of a stretched dollhouse!"



Cinematographer Hoytema remembers the director and production designer scribbling notes on how to design and build the Tesseract throughout principle photography: "I saw that set evolve."

Although it was an advantage to film editor Lee Smith that so much of *Interstellar* was shot in-camera, the Tesseract sequence was one of the most visual effects–heavy in the production, and there wouldn't be final shots until Double Negative finished its CGI work in post-production. Still, Smith knew from the start the sequence would work. "It is bizarre, indescribable," he says. "Visually, it was a long way until we got to the point of what the scene would finally feel like—but, even then, you still got it. The story always [worked] through the Tesseract. There's even a bit of humor there to help you through."

"In the end we really built that set in our world," Nolan concludes. "And it was hugely advantageous, because it depended massively on the performance of Matthew McConaughey and being able to put Matthew up on wires and fly him through this set. He wasn't against green-screen, trying to make something up; he was in a real space, understanding what it meant and how he should react to it. And that was a massive advantage, because it allowed him to access everything emotionally, including helping the audience understand what was going on in the scene.

"There are a lot of things no one is ever going to be able to analyze in watching the film, but I do think audiences would smell a rat if we had not thought the Tesseract through. We wanted to construct a mathematically sound model of how you could display time as a spatial dimension, and it's very true to that. As with using the science behind the black hole, even if they can't understand it, you do feel that this extraordinary thing you're seeing is based on some kind of scientific rules."

ABOVE A scale model of the Tesseract shows the complexity and uniqueness of the concept.
OPPOSITE With the help of the crew controlling his wires, McConaughey explores the Tesseract. "It was like an extremely complex puzzle," Hoytema says of the set.

CHAPTER 10: MUSICAL EXPERIMENTS

SCORING A FILM IS NOT A TASK that waits for filming to end and post-production to begin. Composer Hans Zimmer, whose body of work includes *The Dark Knight Trilogy* and *Inception*, estimates his work on *Interstellar* began in January 2013, before Christopher Nolan finished his screenplay. Nolan first asked Zimmer if he might devote a day to creating music based on a piece of writing he would send him. The director wouldn't reveal what it would be about, but an intrigued Zimmer agreed.

On the appointed day, a formal letter arrived for Zimmer's eyes only. "I opened it and it was a single page, typewritten on this beautiful thick paper, so I knew there was no other copy," Zimmer recalls. "Chris had written the most heartfelt vignette of a parent talking about their child, a boy. I didn't know anything about the movie at this point, but what came across in Chris's writing was the hope you have for your children."

Inspired, Zimmer wrote what he calls a "tiny, very intimate piece" for piano and strings. When Zimmer called the Nolan household to report that the musical piece was ready, the director rushed over to meet the composer. "I played him this very intimate little piano thing," Zimmer says. "The music was discreet and at the same time keeps reaching for some future that never ever resolves. Chris's response was, 'Well, I suppose I better make the movie now.' And my response was, 'What is the movie?' And he talked about this epic science fiction idea. I said, 'But this piece I wrote is intimate and small, it's really about our children and what it's like to be a father.' And Chris goes, 'Yes. But I know the heart of the movie now.'"

The seminal piano piece became a touchstone that Christopher Nolan would return to again and again, Zimmer recalls: "Chris knew that by not presenting me with the mechanics of what the movie is about, but homing in on a very emotional moment, he would get something out of me he wouldn't have gotten otherwise."

The letter was part of the creative collaboration between the two artists. "People ask why the score for *Inception* or the Batman films sounds different from other scores I've done, and it's pretty simple—it's not just me,

OPPOSITE Christopher Nolan looks on as Hans Zimmer plays a few bars from the *Interstellar* score during the recording sessions in London.

it's Chris as the coauthor," Zimmer says. "We have a way of working that just brings out the good side in me, and he's very attuned to and respectful of that. The 'game,' as it were, for this movie was to provide music the audience doesn't expect, so we'll take people on a journey not only with the story and visuals but with the music."

THE MUSICAL LANGUAGE

For *Interstellar*, Nolan and Zimmer departed from the scores of their previous collaborations to create a new musical language. "Honestly, after ten years of working on *The Dark Knight Trilogy* and *Inception*, it seemed like a beautiful opportunity to reinvent our own language," Zimmer reflects. "Chris's idea was that the score be based on cathedral organs, in a completely nonreligious way. A cathedral organ is an amazing piece of technology. The shape of a cathedral and an organ is akin to a spaceship, and the big pipes are like rocket launchers. It seemed like a very different language we could embrace. Everything that I knew about film composing just went out the window, and we started from scratch. So, I spent all of last summer [2013] experimenting on this movie, trying to figure out new things while Chris was shooting."

The composer was initially worried about basing the score on a cathedral organ, as the sounds of certain musical instruments embodied their own potential clichés. "The original piece I wrote was just piano and strings, and when Chris said organ, I went, 'Oh my God, it'll sound like some Gothic horror movie,'" Zimmer recalls. "Each instrument is a cliché—we can't listen to violins without going, 'Oh, that must be the love theme.' So, part of my journey, the game, was to figure out how we could reinvent these things. That is very much at the heart of the movie, this story of how we, as humanity, can reinvent ourselves with science."

TAMING THE BEAST

With cathedral organ music as the basis of the score, composer Hans Zimmer embraced the magnificent splendor of the Salisbury Cathedral organ in England. The "main weapon" at his disposal, as Zimmer puts it, was a digital sampling of all 3,500 pipes in the famed organ. At the press of a key he could call up every sampled pipe, allowing him to virtually play the Salisbury organ in the comfort of his Santa Monica studio. "I can also do the acoustics to fit, because that is paramount to the sound," Zimmer adds. "It was a grand and fabulous thing to have access to."

A major part of Zimmer's creative challenge was learning how an organ works. "I spent quite a few months trying to tame the beast, to really learn this technology," he reflects. "If you think of a church organ compared to a computer—and now I'm getting really geeky and nerdy—it has taken us about six hundred years to get to the same technology in computers. A keyboard in front of a computer sends a key command to the computer that then creates the type on screen, and a church organ works in exactly the same way. The keyboard doesn't make the sound, it sends the command to the bellows that then send air to the pipes. There's science and wonderment and adventure in these instruments, which is very appropriate to the story."

RIGHT Hans Zimmer's *Interstellar* score began with a simple yet emotional piece that communicated the bond between father and child.

As with his production designer, Nolan began by talking story with his composer. Zimmer then wrote pieces of music on the computer that Nolan and editor Lee Smith could listen to and begin integrating into the film. "I would provide Chris with an ongoing sonic vocabulary that he could be inspired by and that would, hopefully, inform his cut," says Zimmer. "Chris and I had to figure out what would make the music different, and not just the sound, but the emotion."

Ultimately, Zimmer produced a solo score that integrated a variety of instruments: "What was odd about this [version of the score] was every note was played by me, all the piano parts, the organ parts. It gave it a weird singularity, one person's absolute interpretation and specificity."

The reaction to the music within the production was enthusiastic. Like a fragile piece of glasswork, Zimmer and Nolan were encouraged to leave it be, that it was perfect the way it was. But the director and composer were plotting to go to London, find a great cathedral and organ, get an orchestra and choir together, and push that singular vision into realms they couldn't anticipate or imagine. Zimmer likened the idea to the famous trip to the Galápagos Islands where Charles Darwin explored his theories of natural selection and evolution—some exciting musical ideas would be discovered, other ideas would be doomed to extinction.

"We were either coming back with only three notes that were great or a lot of stuff," Zimmer recalls. "I had the safety net that everybody liked what I had done, that the music worked the way they wanted it to in the film. On the other hand, I was forever telling people the whole idea of going to London was going to work—but I had no idea if it was going to. The only person who knew my inner thoughts was Chris."

ABOVE Christopher Nolan and Hans Zimmer continue their collaboration at AIR Studios in London.

"There's science and wonderment and adventure in these instruments, which is very appropriate to the story."

TEMPLE OF SOUND

Christopher Nolan and Hans Zimmer, having resolved to score *Interstellar* with an orchestra in a cathedral in London, briefly thought about recording at Salisbury Cathedral. But that was an eighty-mile drive from the city, by Zimmer's estimate, and would be a difficult daily commute for the orchestra. There were also concerns about recording in bustling London. "One of the problems these days is if you want to record in a city, in a church, you get so much street noise," Zimmer notes. "And when making a movie about space, the last thing you want is to hear a police siren go by in the middle of your shot!"

Nolan and Zimmer decided to use a combination of two venues, one the familiar confines of AIR Studios, the recording company founded by Beatles' producer Sir George Martin and his partner John Burgess, located in the former Lyndhurst Road Congregational Church. "It's a church that was turned into a studio because church acoustics are phenomenal," Zimmer says. "The church has survived on showmanship for a long time. If you've ever wandered into a big cathedral and heard music, it's a magnificent sound, an otherworldly sound."

The second venue was the Temple Church, built by the military and religious order of the Knights Templar and consecrated in 1185. The historic church was located off Fleet Street, with the River Thames below, with no traffic and no street noise. "To be in the center of London and have a property like this with no traffic around it, is unimaginable," Zimmer says. "The Knights Templar are buried here, and when you enter this space you really feel the power of the place. It's part of how you get a great performance out of people sometimes—you take them out of the studio and put them in an extraordinary space."

The hundred-strong orchestra, in addition to a sixty-person choir, was largely made up of musical veterans of previous Nolan movies, mixed with some "extraordinary soloists," Zimmer explains, including Roger Sayer, the Temple Church's own organist and director of music.

"On the first day, after we walked into Temple Church and met Roger, he said, 'Would you like to hear the organ?'" recalls Zimmer. "And he played one note and I just knew that we were not only going to be all right, we were going to be magnificently all right, and Chris felt the same way. Whenever Roger hit the lowest notes the windows literally started bulging, because it creates such sonic pressure within that space. It is like the rockets blasting off. Roger became vital in this and was absolutely extraordinary."

Among the unusual aspects of the London sessions was that an orchestra for a film score would normally play with a screen running the scenes from the film—but Nolan and Zimmer did not bring the movie with them, instead relying on their memories. "By not having the immediate gratification of seeing the shot, we were always reminding ourselves about what the feeling was, what the story was that we were trying to tell," Zimmer explains. "Each note, each bit of performance, had to stand on its own and move you emotionally."

Ultimately, the final score was a combination of the historic cathedral (and church turned studio), the handcrafted nature of the musical instruments, and the talent of the musicians. The two weeks of what Zimmer calls "a disciplined perspective" included Christopher Nolan co-running the sessions—if Zimmer was recording at AIR Studios, Nolan would be leading the session at Temple Church.

"It was a delicious puzzle to figure out," Zimmer concludes. "How do you represent the dichotomy of gravity and time? How do you consolidate those ideas as a piece of music and make them musically powerful? Well, I'll tell you—you write a love theme. That's the only metaphor that works. The other game I'm playing is the farther you get away from Earth, corrosion sets in. Tunes that were well defined on Earth become a little more abstract as you start forgetting the little things, and memory plays tricks on the music. And the further we get away in time, the more the music goes through a metamorphosis."

OPPOSITE The orchestra gathers among the effigies of the Knights Templar at the Temple Church, London.

CHAPTER 11: THE FINAL PHASE

WHEN THE FILMING PORTION of a production ends, it does so quickly. At the end of 2013, the mighty *Endurance* set was struck from Stage 30. "You build these things, and it takes so much effort, and then they just vanish," executive producer Jordan Goldberg reflects.

But even with the end of filming, sets coming down and cast and crew dispersing, a new phase in the life of a production begins. Post-production is crunch time for visual effects, scoring a film, and seamlessly cutting together footage into the final story. Editor Lee Smith estimates a million feet of film was shot on *Interstellar* before being honed down to 14,000 feet. "Post-production began in earnest after the Christmas break and then went on for the next six months," Lee says. "It was full-on from the day the camera stopped to the day we finished."

Smith has worked on films filled with CG visual effects but applauds Nolan's practical approach and decries the relentless push to do *everything* in the computer: "It's sort of a headlong rush into an abyss. I certainly understand each process, but doing things in-camera is massively

OPPOSITE Cooper and Brand share an emotional moment.

helpful [in editing]. Visual effects films take a lot longer to get where you need to be. You have to imagine what is going to be in the greenscreen background, but on this film we knew months ahead what the film would be like, because we had amazing in-camera footage [showing the characters] traveling in space. You're not shooting everything on greenscreen, dumping it on a visual effects house, and waiting for them to turn it into something. Then you get hamstrung, because you don't want to trim or drop very expensive visual effects shots. You kind of feel the weight of the world on your shoulders, when you'd rather cut it like a normal film."

From the first rough assembly and "respectable screening film" to the final cut, Smith worked on the Avid, the industry standard nonlinear digital editing system. Lee, whose early, pre-Avid career as an apprentice included physically cutting celluloid, brings the best of both worlds to the editing room.

"Doing things in-camera is massively helpful [in editing]."

"When physically cutting film, you can't just chop frames off, which makes you very precise," Smith reflects. "I've taken that over into the digital world. In the Avid, you have the advantage of being able to access footage instantly, as opposed to waiting for an assistant to walk over to the shelf and load up a reel of film, and then fast-forward to get what you think you might like. But physically cutting film taught me to watch things at a certain pace and rhythm, even to watch things in rewind—I found some of my best stuff going backward! I wouldn't have missed that process for anything in the world."

LEFT Cooper gets a message from Murph. **RIGHT** Cooper is ready for take off.

JOURNEY'S END

For Jonathan Nolan, life had changed from the early *Interstellar* days when he was researching the mysteries of cosmic phenomena. While *Interstellar* was still in production, he and his wife had their first child, a girl. "Even when I was watching early sequences of the film, I was experiencing them on an emotional level completely different from when I wrote the script," he says. "I think I'm going to have a hard time watching this movie. It's very emotional . . ."

Jonathan Nolan brought the space exploration entrepreneur Elon Musk, founder of SpaceX, to Stage 30 to sit inside the *Endurance* and experience the illusion of interstellar travel.

"Elon actually makes spaceships, so I put him in Chris's spaceship," Jonathan says. "We were there for several of the sequences transitioning into the black hole. Basically, we were crammed into this space. Chris was directing, Emma was producing, McConaughey was seated and in his spacesuit. And they turned on the lights and the [front screen] projector, and through the windshield you're looking—and then, the whole set starts shaking! I had forgotten they had the whole thing on hydraulic actuators, and in that moment this spell was cast and you realized all of this effort and money and designing and everyone's hard work had gone into actually creating this reality. For a second we *were* in space, in a spaceship buckling and vibrating. It was a lovely, iconic moment. Being able to cast that kind of spell was truly magnificent. That's what is so wonderful about the way Chris makes movies."

Interstellar seemed to come together at a propitious time, with America cutting back its space program—even as a new breed of space explorer was emerging in the private sector—and China, India, and other countries embarking upon their own ambitious space programs. Many in the *Interstellar* production team saw the film as a call for America to return to greatness.

"A lot of what America used to be, what we stood for, was wrapped up in our space program," producer Lynda Obst reflects. "We showed our best selves to the world through the space program and our ability to use technology for all mankind, as the saying goes, not for drones or bunker bombs. If this movie is one small step [toward] renewing that excitement about what we can do with our best selves, that would be extraordinary."

> "A lot of what America used to be, what we stood for, was wrapped up in our space program."

Purely on the filmmaking side, *Interstellar* was standing against the tidal pull of an industry seemingly transforming into a digital medium. Christopher Nolan acknowledges the ability of audiences to recognize synthetic images, and he likes to recount how one of the first motion pictures, an 1895 Lumière film of a train pulling into a station, reportedly sent audiences fleeing, convinced the train was about to crash into them. "That was a black-and-white film, probably fourteen frames a second, by any standards a very crude image," he reflects. "But because audiences had never seen it before, they were completely taken in by it. What happens is your eye rapidly gets more and more educated. For me, IMAX and a particular efficiency of film technology will mimic the way your eyes see something, and that's fun to play with. One of the reasons I don't work in 3-D is that the so-called 2-D image, properly photographed and projected, is very three-dimensional, that's the whole point of it. You have to be very aware of the depth cues and where the camera is in relation to the actors. You don't slap a zoom lens on; you have to move the camera close to the actors if you want to feel closer to them. All that pays dividends.

"Human beings are capable of synthesizing a lot of different inputs and analyzing them in a complicated way to

OPPOSITE *Interstellar* features some of the most elaborate and innovative sets created for a motion picture.

understand something, and that's what movies have always been," Nolan concludes. "You take an image, sound and music, you synthesize and create a world in their minds, create an experience. That's what is always at play, particularly the bigger films where you're really trying to give the audience the feeling of being somewhere else."

By May, with the release still half a year away, *Interstellar* visual effects work was ahead of schedule, a director's cut had been assembled, and the early marketing push included a new poster and the first full-length theatrical trailer—the tagline displayed on both summed up everything for Christopher Nolan.

During a sunny, balmy post-production day in May at the cutting room in Los Angeles, the director reflected on how the creative journey had come full circle: "Interestingly, with the trailer and the poster that's come out, we're leading with my favorite line: 'Mankind was born on Earth. It was never meant to die here.' That, to me, is everything the film is about. I used that idea as a jumping-off point for an exploration about human nature in the tradition of the great adventure stories I love—whether *The Treasure of the Sierra Madre* or *Greed*—that dealt with human beings in extreme situations and what that tells us about who we are. This film is very much about what it is to be human, but the important thing that propels the story, emotionally, is this idea that the day is coming when we're going to leave this planet and go other places. And I completely believe it. You meet someone like Elon Musk who tells you he's going to Mars, that we're going to be colonizing planets. And you think, 'Why not?'

"*Interstellar* is about leaping forward in time, leaping forward in human experience, and saying, Where might we go from here? It's presenting the spreading off from our Earth and through the galaxy as an inevitability of human evolution, not as a fanciful science fiction conceit. That, for me, is what the whole thing is about—what's the next step in human evolution? And it must be to leave Earth. It has to be. There's a whole universe out there to be explored."

RIGHT Between takes, the director and star of *Interstellar* take a moment to reflect.
FOLLOWING PAGES The Ranger cuts through the clouds high above the ice planet.

NOTES

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Quotations from the actors were supplied through transcripts of the production's electronic press kit interviews.

AUTHOR ACKNOWLEDGMENTS

My thanks to stellar editor Chris Prince, and Insight Editions, for sending me on this voyage, and to the Nolan production for its support. A special tip of the old chapeau to the indomitable Josh Anderson for coordinating everything, and to Isabella "Izzy" Hyams, who took on the difficult task of arranging interview sessions, wrangling images and approvals, and so much more. And here's a shout-out to Shane Thompson, Andy Thompson, Hillary Cunin at the Syncopy production office, Rachel Abarbanell at Lynda Obst's office, and Cynthia Park in Hans Zimmer's office, for their help and hospitality.

Special thanks to the talented filmmakers who provided exclusive interviews for this book: Christopher Nolan, Emma Thomas, Jonathan Nolan, Lynda Obst, Jordan Goldberg, Jake Myers, Nathan Crowley, Hoyte Van Hoytema, Paul Franklin, Scott R. Fisher, Mary Zophres, Luisa Abel, George Cottle, and Lee Smith.

My deep appreciation to my agent, John Silbersack, and his outstanding assistant, Anna Qu. I'll also share the love with the family, especially my talented mother, who proofreads everything! And to Mike Wigner, San Francisco's iron man bicycle messenger—Wig, it's a wrap. See you at Vesuvio's.